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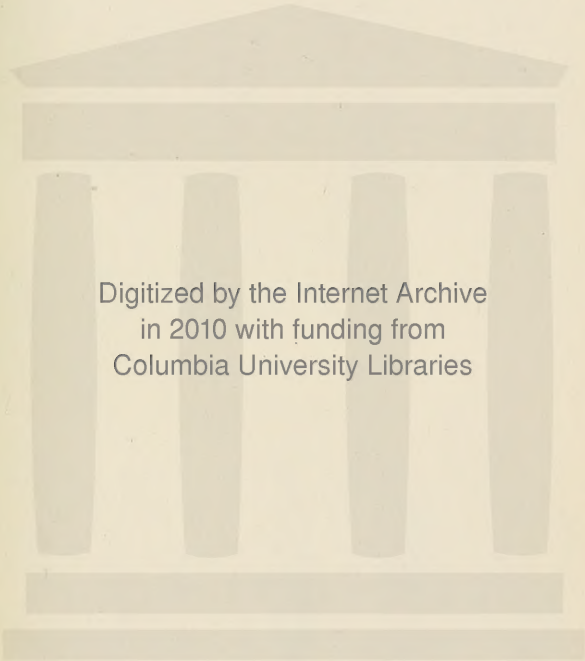
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SURGICAL TREATMENT

A Practical Treatise
on the Therapy of Surgical Diseases for the Use of
Practitioners and Students of Surgery

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SURGICAL TREATMENT

THE TREATMENT OF HERNIA

Hernia may be treated by non-operative mechanical methods or by operation. Mechanical appliances are to be used only in cases in which operation is contraindicated, or in which operation for some reason must be deferred. It should be understood that the ideal treatment of hernia is by operation, the object of which is to restore the parts to their natural relations.

NONOPERATIVE TREATMENT

By nonoperative or mechanical treatment is meant the application of a truss, belt, or support intended to control the hernia or prevent its increase in size. For inguinal and femoral hernia the truss is used, for umbilical and ventral hernia a belt and pad are employed.

The best form of **truss** is that made with a steel spring and a pad (Fig. 1460). The hernia should first be reduced and then the pad placed over the ring. The spring which passes at least halfway round the body holds the pad in place over the hernial opening and prevents its escape. This is called the *frame truss* (Fig. 1461). It is covered with rubber and leather.

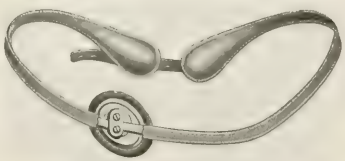


Fig. 1460.—Frame Truss.

The pad may be an air or water cushion. Some are filled with glycerin. Some pads are made of hard rubber. A truss with a high waist frame may be used for small hernias (Fig. 1462). Such trusses may be single or double (Fig. 1463).

The truss has no curative value except in young children. In adults it is very exceptional to find that a hernia has gotten well under the influence of a truss. When this is reported to have occurred usually there was no hernia to begin with. The natural tendency of a truss is to weaken the parts, and make the wearing of a truss more necessary.

Femoral hernia requires a peculiar type of truss (Fig. 1464). In some cases a perineal strap is necessary to prevent upward displacement. Large hernias require especially constructed trusses with large pads (Fig. 1465).

For the mechanical support of umbilical and ventral hernias in adults an *abdominal belt* (Fig. 1466) is used. A pad may be attached to the inside of this belt in such a way that it shall make pressure at the hernial opening.

Belts of this kind are made of strong duck with whale bones to keep their shape and rubber elastic to provide constant and even pressure.

For *umbilical hernia*, a frame truss is most effective. The pad should be larger than the hernial opening (Fig. 1467).

The *umbilical hernia* of children cannot be treated with a belt because it cannot be kept in position. The best appliance is a wooden button-mold covered with adhesive plaster and held firmly in the hernial opening by means of a strap of zinc oxid adhesive plaster, about 5 cm. (2 inches) wide, and encircling the body at the level of the umbilicus. By washing the skin well with soap and water, rubbing it with alcohol and water, drying it and then applying zinc oxid powder, this treatment may be continued indefinitely. The plaster may be renewed as often as desired. When any part of the skin

Fig. 1461.—Frame Truss Applied to Inguinal Hernia.

becomes irritated, a layer of gauze and zinc oxid may be placed under the plaster at that area. This treatment usually results in the cure of the hernia in children.

Irreducible hernia in which operation is contraindicated must be treated with the object of preventing increase in size and securing comfort for the patient. Irreducible scrotal hernia may be supported by a firm bag of duck, made in such a way as to give gentle pressure upward toward the groin.

Inguinal *hernia in infants* and young children is best treated by a spring truss. Bandages and other appliances are less cleanly. In young children the wearing of a truss may be expected to be followed by the spontaneous healing of the rupture. In infants a truss should be applied as soon as an inguinal hernia is discovered. It should be worn constantly, except for daily bathing to keep the skin healthy. A cure may be expected by this treatment in children under four years of age. The younger the child, the sooner the truss is applied, and the more constant the retention of the

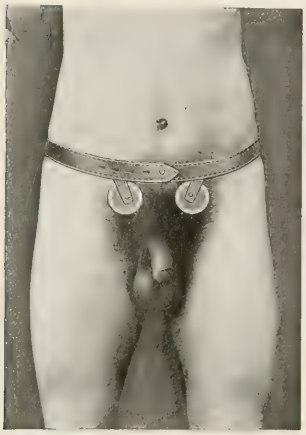


FIG. 1462.—HIGH FRAME TRUSS APPLIED TO DOUBLE INGUINAL HERNIA.

FIG. 1463.—DOUBLE INGUINAL FRAME TRUSS APPLIED TO DOUBLE INGUINAL HERNIA.

FIG. 1464.—TRUSS APPLIED TO FEMORAL HERNIA.

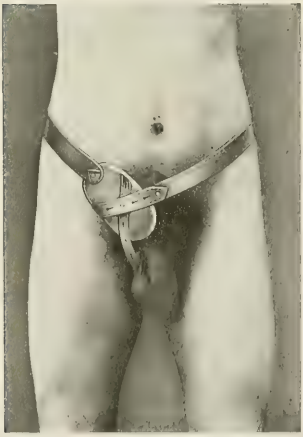


FIG. 1465.—LARGE PAD FOR ESPECIALLY LARGE INGUINAL OPENING.

hernia, the surer is the cure. Operation is not indicated in children under four years of age if the rupture can be controlled by a truss. The truss should be worn until the hernia is cured. This means about a year. If after two years the hernia is not cured and the child has passed the age of four, or if the hernial opening does not show a gradual diminution in

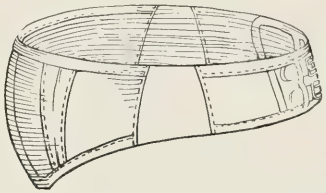


FIG. 1466.—ABDOMINAL BELT FOR VENTRAL OR UMBILICAL HERNIA.

size, or if the opening is unusually large, or if the truss is disagreeable to the child, or if it does not control the hernia, operation is indicated.

Prognosis with a truss so far as retention of the hernia is concerned is good. A well-fitting truss will hold the ordinary inguinal or femoral hernia and permit of an active life. There is always danger of some unusual exertion or motion causing a slight displacement of the truss and at the same

FIG. 1467.—FRAME TRUSS APPLIED TO UMBILICAL HERNIA.

time an increase of intra-abdominal pressure and extrusion of the hernia. Under such circumstances strangulation is very apt to occur. For this reason a man with a truss-controlled rupture carries with him constantly a source of danger. In femoral hernia commonly, and in inguinal hernia less frequently, omentum is apt to find its way into the sac and become

adherent. In umbilical hernia this is commonly the case. Irreducible hernia is always a menace to life, and should be operated upon unless the contraindications against operation are positive.

COMPLICATIONS OF HERNIA

The most common complications or accidents of hernia which require treatment are irreducibility, strangulation, obstruction, and inflammation. These may occur separately or in combination.

Irreducibility is best treated by operation for the radical cure of the hernia. If there are contraindications to operation the patient should be put to bed and kept quiet with a small diet. Gentle taxis may be applied to test the diagnosis and indications for treatment.

The *application of taxis* requires judgment. Under no circumstances should it be so forceful as to damage the contents of the hernial sac. Immediately after the occurrence of an irreducible hernia congestion may be relieved and a better prospect of reduction secured by the use of cold applications. Cold should not be used on old people or in the infirm, but hot applications are to be preferred. After the application of heat or cold for half an hour, another attempt at taxis may be made. Taxis should be applied with the patient lying flat on the back. The whole of the hernial mass should be compressed evenly, the hand or fingers forming a cup to embrace it. Gentle manipulating pressure should be made in the direction of the path through which the hernia escaped. By elevating the pelvis and lowering the thorax the aid of gravity is secured. Effort should be made to compress the whole of the hernia, the neck as well as the fundus. Usually it is better to compress the neck with one hand and make reducing pressure upon the fundus with the other hand.

The *dangers of taxis* are contusion and wounds of the sac contents, rupture of bowel, rupture of sac, reduction of sac and contents *en bloc*, and reduction into another sac. In either of the two latter cases the hernia may seem to disappear but the symptoms persist.

The patient should be kept in bed, and every two or three days taxis may be tried. Cathartic medicine should not be given. It is advantageous to move the bowels by enema. If reduction is not accomplished and operation is contraindicated, the hernia must henceforth be supported with a bag or cup-shaped pad on a spring truss in order to prevent its enlargement. Operation should be done if possible, as irreducible hernia is very prone to become obstructed or strangulated.

Strangulation is the great danger of hernia. When this accident has occurred gangrene of the hernial contents is imminent, the circulation is obstructed, and to this is added acute intestinal obstruction if the bowel is involved. The surgeon has one imperative duty, and that is to relieve the strangulation. If this is promptly and properly done the hazard is but slight; if it is delayed the danger to life increases with the lapse of time. The largest proportion of recoveries are among those cases which occur near surgical centers where operation is done at once. Where skillful surgical attention can be secured, it is best that no attempt at reduction at all should be made. Under these circumstances, when operation is done within a few hours after the occurrence of strangulation, the mortality is very low. Even gentle taxis damages strangulated bowel, and if the patient is within access of competent surgery he should have the benefit of it with the strangulated structures preserved in the best possible condition.

When attempts at taxis seem justified, it should be applied with the

utmost care. The pelvis should be elevated and the methods of taxis, described above, should be applied. Not more than five or ten minutes should be given to taxis. When it is known that the sac does not contain intestine less gentleness is demanded.

In cases of enterocele in which the symptoms are extremely acute from the onset it may be assumed that the constriction is very tight and the danger of perforation of the bowel is great. In these cases operation without attempts at reduction is to be done. In such cases even gentle taxis may cause a tear of the bowel and escape of intestinal contents into the peritoneal cavity.

In cases in which strangulation has existed for eighteen hours or longer, taxis is very dangerous. Taxis is contraindicated in cases in which the hernia was of the irreducible type before strangulation occurred.

The local use of ice in the strong, and hot applications in the old and infirm as already described, may be of service.

The aspiration of the fluid contents of the sac can not be regarded any longer as good surgery. It is true that cases which have suffered most unconscionably unsurgical abuse have recovered after sloughing of the sac and skin and the spontaneous formation of a fecal fistula or unnatural anus.

The *prognosis* depends most upon the length of time the strangulation has lasted. The smaller the size of the hernia the better the prognosis. In strangulated umbilical hernia the mortality is very high.

The *operative treatment* should be the same as that for the radical cure of hernia. Division of the constricting ring should be done as soon as it is exposed. After the ring is divided the strangulation is relieved, and the bowel should be studied to observe whether its vitality has been so damaged as to make resection necessary. If the color of the gut promptly returns, it may be restored to the abdomen and the operation completed. If there is some question about it, towels wet with warm saline solution may be applied for a few minutes. If there are devitalized areas or if the circulation of the whole loop is not restored, it should be treated according to the rules laid down for *gangrene of intestine*. After resection of intestine or other operation not requiring drainage the radical cure of the hernia should be proceeded with.

It may be necessary on account of the condition of the patient to complete the operation as expeditiously as possible. When this is necessary an artificial anus may be made, a drainage tube inserted, or other treatment applied, as described for intestinal gangrene and obstruction, and the permanent closure of the wound deferred.

The decision as to whether bowel has lost its vitality or not is sometimes difficult. Bowel that is destined to become gangrenous is dull and without gloss; its color is dark or grayish; it has not the elasticity of living gut but is soggy or doughy; the pulsations of its mesenteric vessels can not be seen or felt; and its circulation does not return after hot compresses have been applied for ten or fifteen minutes. G. Marion has aptly said, "Apprendre à être propre constitute le premier devoir."

The decision as to whether resection (see Vol. II, page 636) shall be done or an artificial anus (see Vol. II, page 685) made in case gangrene is present must depend upon several circumstances, chief among which are the skill of the surgeon and the condition of the patient. It should be borne in mind that the operation is for two conditions: acute intestinal obstruction (see Vol. II, page 595) and gangrene of the bowel (see Vol. II, page 609). There are certain general principles to be observed in these conditions which apply to all cases.

Resection for gangrene is the ideal treatment; but the necessity for haste may make the more simple formation of an artificial anus the operation of expediency.

If a free relief of the obstruction has been secured, and the bowel looks gangrenous, it is not necessary to do either operation. In the event of a low state of the patient's vitality, or of the surgeon's skill, the ring may be enlarged so as to relieve the bowel of compression; the loop may be drawn down until healthy gut appears on either side of the damaged segment and then a few stitches in the healthy bowel may be inserted to fix it to the wound in such a way that the loop cannot return into the abdomen. It should be placed so that the intestinal contents may not be obstructed by angulation or pressure. A dressing covered with vaselin to prevent adhesions is applied, and the patient returned to bed. This treatment may be applied in doubtful cases. If the bowel is viable, it is dissected free and returned to the abdomen at a subsequent operation and the hernial opening closed. If the bowel perishes, an opening sloughs through its wall and an artificial anus is established. This occurs after adhesions have closed off the general peritoneal cavity. If there is need of relief of the intestinal contents at the time of the original operation a tube may be fixed in the bowel by means of a purse-string suture, and the intestine drained and washed out when necessary (see Acute Intestinal Obstruction, Vol. II, page 595). Or a spur may be made so that a later closure may be facilitated (see Vol. II, page 583).

In cases of *strangulated omentum* without involvement of the bowel, the damaged omentum should be tied off and removed.

Obstructed hernia is so called because of fecal stasis developing without strangulation. Two things should be avoided: taxis and cathartics. The patient should be placed on a firm mattress with the pelvis elevated. Hot compresses should be applied to the hernia, making gentle pressure. The most important treatment is the administration of warm enemata. A liter (1 quart) of warm water should be injected slowly into the bowel, retained for a few minutes, and expelled. This operation should be repeated every three or four hours until the fecal accumulation at the hernia has been relieved. An obstructed hernia easily becomes strangulated, and the treatment should then be modified accordingly.

Inflamed hernia results from irritation of a truss, enteritis, obstruction, taxis or any condition causing infection of the sac. This is one of the dangers inherent in irreducible hernia. It should be treated by enemata to relieve the intestinal stasis, warm local applications, and incision and drainage when infection of the sac is present. Cathartics and taxis are to be avoided. Reduction and radical cure cannot be attempted until the infection has subsided. If incision and drainage of the sac are required, a radical operation for the cure of the hernia should be done later. Enlargement of the opening will often be found necessary to secure good peritoneal drainage. Such enlargement is made by splitting the external oblique. If a radical operation is not done recurrence of the hernia may be expected.

SPECIAL FORMS OF HERNIA

Operations for the Radical Cure of Inguinal Hernia.—The operation which I have been doing since 1890 bears no surgeon's name. It is the simple and natural procedure for the radical cure of inguinal hernia, and embraces no extraordinary features. Its object is to restore the parts to their normal relations and at the same time give some additional strength with the view of preventing recurrence. The steps are as follows:

Exposure of the Canal.—A straight incision is made about 2 cm. (¾ inch) internal to Poupart's ligament. It begins internal to the anterior-superior spine of the ileum and passes downward and inward parallel with the ligament for a distance of 9 or 10 cm. (3½ or 4 inches), ending over the external opening of the canal. The skin and superficial fascia are dissected back exposing an area of the aponeurosis of the external oblique at least 4 cm. (1½ inches) in width. The aponeurosis is then split, in the direction of its fibers, from the external ring upward and outward nearly to the upper end of the skin incision. The split is parallel with Poupart's ligament, and about 2.5 cm. (1 inch) above it. This is done upon a grooved director (Fig. 1468) or with a probe-pointed knife or scissors. Only the aponeurosis

FIG. 1468.—OPERATION FOR INGUINAL HERNIA.

The skin and superficial fascia have been incised. The aponeurosis of the external oblique muscle is exposed, a grooved director is passed behind it, and the fascia is in process of being divided.

should be divided, care being taken not to injure the ilio-inguinal nerve. The edges of the aponeurosis are then caught by clamps and lifted forward while the aponeurosis is freed from the underlying muscle, outward until the inner side of Poupart's ligament is well exposed, and inward nearly as far as the rectus muscle. The opening in the aponeurosis is then held apart with retractors, and the cord and sac are picked up between the fingers. One finger penetrates the connective tissue behind the cord and lifts it forward. The muscular fibers lying in front of the cord are bluntly pressed upward, and the whitish dense structure of the sac exposed. The sac, lying in front of the cord, is grasped with a pair of forceps (Fig. 1469).

Treatment of the Sac.—In acquired hernia the sac is then dissected free from the rest of the cord by means of a blunt instrument or the finger. A

blunt retractor is inserted at the external ring and traction made outward and upward. An assistant draws the cord downward while the sac is being dissected free. The separation of the sac is carried on until the place is reached where it begins to widen out into the general peritoneum. Another clamp is then applied, and the sac is opened and split upward on its anterior surface. The interior of the sac is examined to see that no viscera are adherent to it. A curved needle, threaded with chromic catgut, then catches the sac wall well up toward the general peritoneum, the ligature is thrown around the base of the sac and tied. While this ligature is being tied the sac should be pulled well down, and its interior exposed so that it may be seen that no omentum or bowel is embraced by the ligature (Fig. 1470).

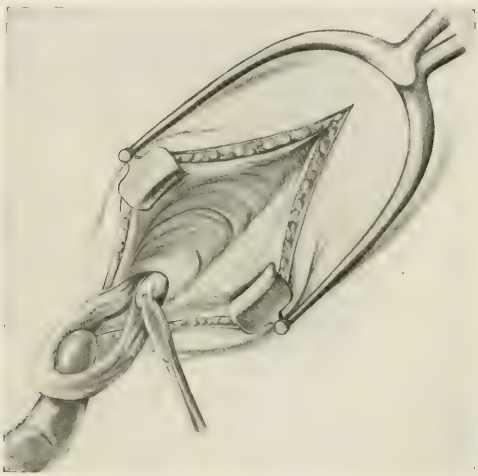


FIG. 1469.—OPERATION FOR INGUINAL HERNIA.

Isolation of cord. Retractors hold apart the aponeurosis. The cord is drawn down. The sac follows the cord. The sac is identified and its apex caught with a clamp.

The sac is then cut away, leaving enough stump to prevent slipping of the ligature.

Closure of the Canal and Ring.—The cord is then dropped into its natural bed. The skin and superficial fascia are retracted, and the lower edge of the aponeurosis lifted up. A curved needle carrying chromic catgut or kangaroo tendon is then passed from below upward through the lowest part of Poupart's ligament; the needle is carried in front of the cord, and thence forward through the conjoined tendon, muscle, and fascia, lying to the inner and upper side of the external ring. This suture through the conjoined structures should be guided by the finger; it should not penetrate the peritoneum. It should embrace the transversalis fascia, the conjoined tendon of the transversalis and internal oblique muscles, and the aponeurosis of the external oblique. It is then carried back across the front of the cord, passed

through Poupart's ligament again a short distance anterior to the beginning suture, and as the edge of the outer lip of fascia is lifted up, the two ends are tied on the outer side of the ligament (Fig. 1471). This is the most important suture in the operation. It should be placed sufficiently low to leave an opening only large enough for the passage of the cord. The danger of making the opening so small that the cord will be unduly compressed is not great. The succeeding sutures pass through Poupart's ligament from below, cross in front of the cord, penetrate the muscular and aponeurotic mass forming the inner wall of the canal, thence pass back, through Poupart's ligament to be tied on the outside of the latter (Fig. 1472).

Two important points should be observed: (1) All loose and excessive areolar connective tissue should be removed from the cord and canal so

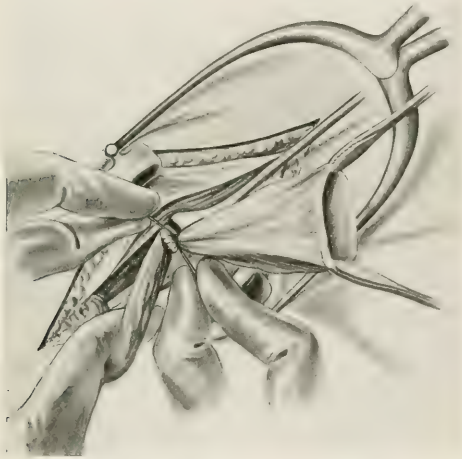


FIG. 1470.—OPERATION FOR INGUINAL HERNIA.
Treatment of the sac. The cord is drawn down, the sac is cut open, emptied of bowel and ligated at its neck.

that it shall not intervene between the sutured surfaces; and (2) the suture passed through the inner wall of the canal should embrace a good thick mass of muscle and aponeurosis.

While these sutures are being inserted the lower edge of the aponeurosis continuous with Poupart's ligament should be held forward by an assistant who holds it in such a way as to coöperate with the surgeon in the passing of the needle. The surgeon's left index-finger is held behind the conjoined tendon, the transversalis and internal oblique muscles to guide the needle. Five or six of these sutures suffice to close the rings and canal (Fig. 1473). When they have been applied, the cord lies at the bottom of the canal; and the conjoined tendon and muscles, constituting the internal and wall of the canal, have been united to Poupart's ligament.

If the oblique muscle is weak and thin, the rectus may be used in connec-

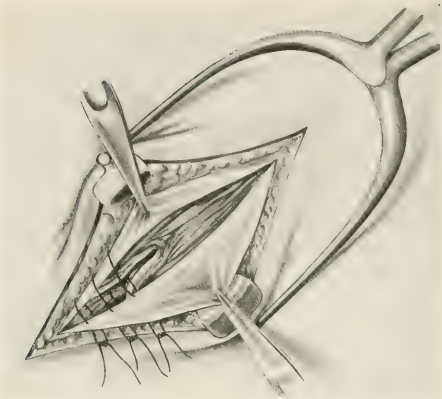


FIG. 1471.—OPERATION FOR INGUINAL HERNIA, CLOSURE OF CANAL.

The first sutures applied. Ligament held up with forceps. Sutures at bottom, to include conjoined tendon and aponeurosis, ready to be tied outside of Poupart's ligament.

FIG. 1472.—OPERATION FOR INGUINAL HERNIA. CANAL CLOSED.

Showing sutures tied on outer side of Poupart's ligament. Free edge lifted up with forceps.

tion with it. The sheath of the rectus is opened on its outer border for a distance of 8 cm. (3 inches). After suturing the oblique muscle under the shelving reflection of Poupart's ligament, the same thing is done with the outer border of the rectus, superimposing it upon the oblique.

Overlapping the Aponeurosis.—The next step in the operation consists in closing and, at the same time shortening, the aponeurosis. This is done by placing the lower leaf in front of the upper one. With the same size of needle and catgut as already used, the needle is passed through Poupart's ligament close to the first suture that was passed, and like it from below upward. Thence the needle is carried in front of the closed ring, and pierces from below upward and inward the front of the aponeurosis and conjoined tendon on the upper and inner side of the ring. This suture should include a good big grasp of the fascia. It should be placed on the anterior surface

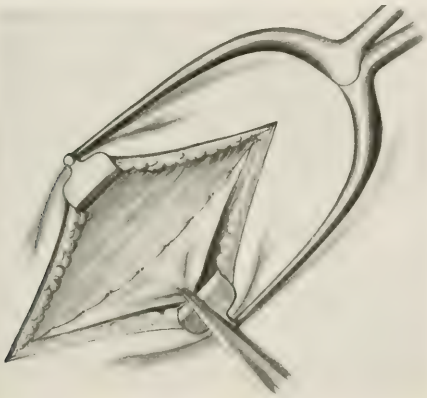


FIG. 1473.—OPERATION FOR INGUINAL HERNIA, CANAL CLOSED.

The sutures closing the canal have been applied. The aponeurosis, continuous with Poupart's ligament, is lifted up as a free flap, showing appearance on inner side of Poupart's ligament.

of the conjoined tendon so as to cause the lower end of Poupart's ligament to ride over the tendon near the first knot. From this point a continuous running lock-stitch suture is applied, drawing the lower leaf of the aponeurosis of the external oblique, connected with the inner side of Poupart's ligament, up over the aponeurosis of the external oblique internal to the opening. This simply causes the lower lip of the aponeurosis to overlap and lie in front of the upper lip. In taking this suture the needle is passed some distance from the free border of the upper lip. It fixes the free edge of the aponeurosis which passes from the inner side of Poupart's ligament, to the flat anterior surface of the aponeurosis of the abdomen with enough tension to give an overlapping of 2.5 to 4 cm. (1 to 1½ inches) at its middle (Fig. 1474).

Closure of the Superficial Parts.—The skin wound is closed with a subuticular suture of linen or silver wire or by a running through-and-through

suture of fine catgut or silk. If there is much subcutaneous fat a running catgut suture may be used to close the deep layer of the superficial fascia before the skin suture is applied. Or in a fat abdomen deep silkworm gut may be used with superficial stitches of silk between.

A firm spica bandage or a pelvic binder with a perineal strip should hold the dressing in place. The scrotum should be supported by a suspensory.

Amplifications.—There are *three important steps in this operation:* (1) Isolation and closure of the sac; (2) closure of the inguinal canal; and (3) shortening and closure of the aponeurosis of the external oblique.

In the isolation and closure of the sac, blunt dissection usually frees the sac from the rest of the cord, and in most cases ligation of its neck is the best method of closure. If the sac is congenital, some cutting with the scissors is required; by carefully identifying the cord, there is little danger of injuring

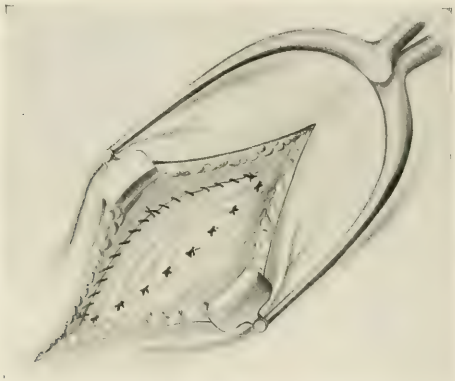


FIG. 1474.—OPERATION FOR INGUINAL HERNIA.

Aponeurosis sewed. The lower lip of the aponeurosis has been placed in front of the upper and inner lip and sewed to the flat surface by means of a continuous suture, thus causing an overlapping of the fascia.

it; and at the lower end of the sac it should be cut off in such a way as to leave a tunic for the testicle which should be closed by suture. If the sac is wide at its neck it is better to catch it with clamps at its upper end, cut it away, and sew the peritoneal opening just as is done in operative wounds through the anterior abdominal wall. A small sponge on a holder or a narrow spatula may be used to keep the bowel pressed away while the suture is being applied. Where the sac is tied off, in order to bring the peritoneal infundibulum above the weak place, the suture may be left long, the two ends each threaded on a needle and passed up the canal and thence forward and through the muscle of the abdominal wall, and tied, thus drawing upward the stump of the sac and placing the funnel-like dimple behind strong muscular wall rather than opposite a path of weakness.

The internal oblique muscle as it arches over the external ring should not be cut; it can be retracted enough to allow of isolation of the sac.

In this dissection the *iliohypogastric nerve* should be spared. It lies

between the twelfth dorsal and the ilio-inguinal as they pass downward and inward from the side of the lower abdomen. They all communicate with one another. They supply motor fibers to the transversalis, internal and external oblique, and rectus muscles, and have to do with the nutrition of the tissues of the groin and iliopubic region. As the aponeurosis of the external oblique is split and retracted, so that the muscle is uncovered, the iliohypogastric nerve will be seen passing across the field of operation, lying on the muscle. It enters the aponeurosis of the external oblique about 2.5 cm. (1 inch) above the external ring (Fig. 1475).

The nerve may best be avoided by beginning the splitting incision in the aponeurosis at its upper and outer end, by a short incision, and then passing curved scissors beneath the aponeurosis, and lifting it away from the muscle before cutting further. If the inner end of the incision of the aponeurosis is kept well down toward Poupart's ligament, the nerve will not be cut.

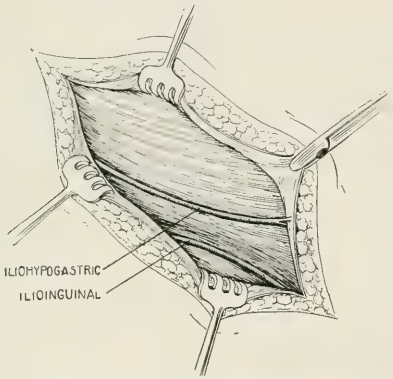


FIG. 1475.—NERVES OF THE GROIN INVOLVED IN OPERATION FOR HERNIA. The nerves are here shown comparatively larger than normal for purposes of demonstration.

In the closure of the inguinal canal in large and sliding hernias care should be taken not to injure the bladder. A good closure of the lower part can not be effected unless the cord is freed of all superfluous tissue. In old hernias and in irreducible hernias there may be considerable of this. Everything should be dissected away leaving only the vas deferens, the artery, essential veins and nerve. It is unwise to attempt to close the canal over a cord which is unduly bulky. When haste is called for, a more rapid operation may be done by passing the suture through the shelving edge of Poupart's ligament, thus embracing the latter with one motion, and tying on its inner side, instead of the outer side as above described (Fig. 1476).

The shortening and closure of the aponeurosis need not be done by the overlapping method if there is a demand for haste in completing the operation. There is a still more rapid method; it consists in a simple running suture of chromic catgut taken so far from the edge of the fascia in the inner column as to shorten the fascia and close the canal. Whatever method is pursued, before laying one surface of fascia upon another they should be well cleared

of connective tissue so that nothing shall intervene to prevent solid coalescence of the two layers.

Remarks.—Rubber gloves should be worn by all hands involved in operations on hernia. The handling of the tissues should be gentle. Infection spoils the hope of radical cure.

Throughout the operation, the *nerves should be spared* as much as possible. It behooves the surgeon to be just as familiar with the nerves of the groin as with the other structures. To include a nerve in a ligature or unnecessarily cut a nerve means subsequent pain, possibly neuritis or weakness of the structures from nutritive derangement sufficient to cause recurrence. The hypogastric branch of the iliohypogastric, the ilioinguinal and the genital branch of the genitocrural are the important nerves.

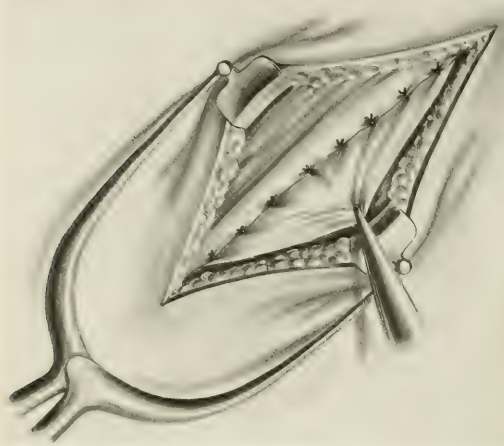


Fig. 1476.—Tying Sutures on the Inner Side of Poupart's Ligament in Operation for Inguinal Hernia.

The best *suture material* is No. 2 plain catgut for the peritoneal suture and for tying vessels. Medium-sized kangaroo tendon or chromicized catgut is best for suturing the pillars of the canal, fascia and muscles. Plain or fine chromicized catgut is best for the subcuticular skin suture.

After-treatment requires that the dressing be kept firmly retained in place. The suture may be removed at the end of a week or ten days. The patient may sit up at the end of two weeks and walk about on the seventeenth day. A snug spica should be worn until the end of the third week. The wound should not be regarded as ready for muscular strain until a month after operation. No support should be worn after that.

Operation involving transplantation of the cord (Bassini) has been most widely adopted of any operation because it was introduced at a time (1888) when unsatisfactory operations were being done and because it presented real advantages which are entirely independent of transplantation of the cord. The incision is made about 1.3 cm. (½ inch) internal to Poupart's

ligament. The aponeurosis of the external oblique is exposed and divided as described above on a grooved director, and dissected free from its underlying

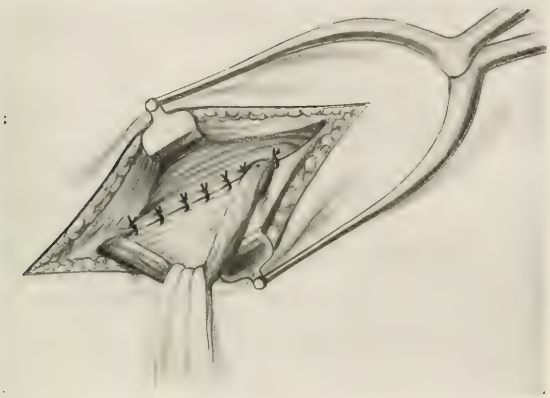


FIG. 1477.—CANAL CLOSED BY METHOD OF BASSINI.

structures. The sac is isolated, tied at its neck and cut away. If it is large it is sutured at the neck. The cord is then held forward, by means of a strip of gauze after being isolated by bluntly stripping back its loose tissue,

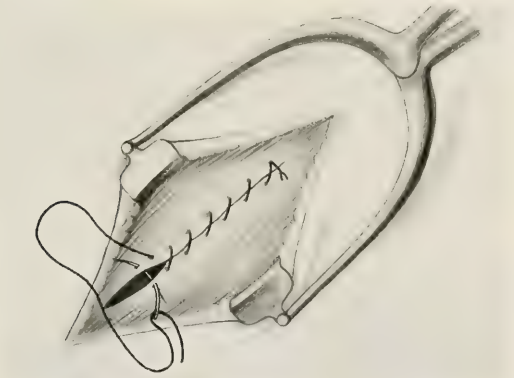


FIG. 1478.—APONEUROSIS SUTURED OVER THE CORD BY METHOD OF BASSINI.

and the canal is closed behind it. The lower borders of the conjoined internal oblique and transversalis muscles are sutured to Poupart's ligament by

interrupted sutures of chromic catgut or kangaroo tendon. The aponeurosis is retracted and the cord held forward while the canal is being closed. The lowermost suture should pierce the internal oblique muscle, the reflected portion of the aponeurosis of the external oblique, the conjoined tendon, and the transversalis fascia, suturing them all to the lower extremity of Poupart's ligament. The upper suture just touches the cord as the latter is lifted vertically. Five or six sutures, thus grasping the muscular mass of the internal wall of the canal and ring on one side and the shelving edge of Poupart's ligament on the other, close the opening (Fig. 1477). By lifting out the cord in this manner a complete closure of the lower end of the opening is possible. The split aponeurosis is then united by a continuous suture (Fig. 1478), and the skin wound closed.

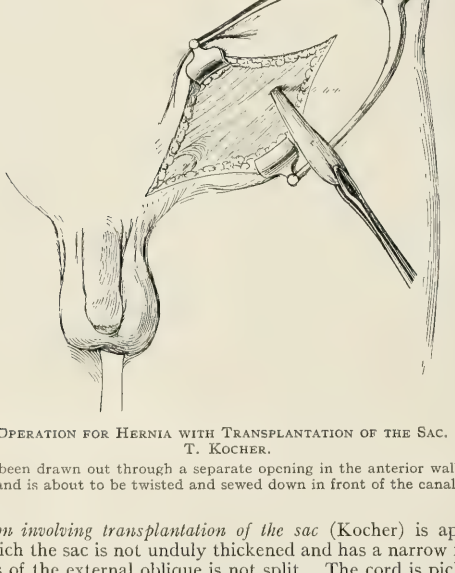


FIG. 1479.—OPERATION FOR HERNIA WITH TRANSPLANTATION OF THE SAC. METHOD OF T. KOCHER.

The sac has been drawn out through a separate opening in the anterior wall of the canal and is about to be twisted and sewed down in front of the canal.

Operation involving transplantation of the sac (Kocher) is applicable to cases in which the sac is not unduly thickened and has a narrow neck. The aponeurosis of the external oblique is not split. The cord is picked up and the hernial sac isolated down to its neck. A small puncture is made in the aponeurosis about 4 cm. (1½ inches) above and external to the external ring. Through this puncture an artery clamp is passed, penetrating the external oblique muscle, into the canal. The tip of the clamp is passed downward and inward, in front of the cord and caused to emerge at the external ring. The tip of the sac is then grasped by the clamp and drawn out through the muscle and aponeurosis (Fig. 1479). The sac is twisted by rotating the clamp three or four times on its long axis. It is then laid down in

front of the aponeurosis and embedded in it by sewing the aponeurosis over it. The closure of the external ring should be effected by the method described above.

Operation without removal of the sac may be done in cases in which haste is necessary and in cases in which the presence of the sac may do no harm. The removal of the sac as a routine procedure is a tribute to tradition. I have often left it with no apparent disadvantage. After exposing the hernia, opening the sac, and emptying it of its contents, it should be dissected free about its neck so that it is quite isolated. A purse-string suture should then be inserted inside the sac, with a curved needle, as high in the neck as possible. The neck below the suture should be scraped with a knife to excite adhesions, and the suture tied. The upper part of the sac may then be painted with iodin. The two ends of the suture should be left long and each end threaded with a needle. These ends should be passed through the sac at opposite sides, then carried up the canal, passed through the fascia constituting its anterior wall and tied on the front of its fascia.

Thus the entrance to the sac is closed, adhesive inflammation is promoted, and the dimple which represents the former place of entrance is dislocated upward and outward beyond the weak place in the canal.

If the sac is large it need not be isolated, the simple purse-string suture placed as high as possible, followed by scarification of the neck below the suture suffices. Nor is it absolutely necessary to pass the two retaining sutures up the canal. These are steps which, while not necessary, contribute something to insuring the success of the operation.

If desired, the whole inside of the sac may be treated with iodin with the view of setting up an occlusive inflammation as in the treatment of hydrocele. Such sacs if left may become the seat of hydrocele, but this should be expected only rarely.

In the congenital form of hernia the cord should be excluded by the purse-string suture. If the operation is conducted in such a way that the two sutures are to be passed through the anterior wall of the canal at a higher point, in some cases it will be found best to make an incision on either side of the cord, thus allowing it to drop away from the sac, as the purse-string is tightened and the neck dislocated upward.

In old hernias with large rings, a transverse incision may be made through the peritoneum at the neck, circumcising the sac at the ring. The peritoneum is then stripped up and sutured thus closing off the peritoneal cavity from the sac. The sac is obliterated by suturing its walls together inside. The closure of the pillars and reinforcing of the ring are then proceeded with.

I have often practised suturing together the walls of the sac from the inside by a rapidly applied running suture, after painting it with iodin, thus obliterating the sac even in cases in which it could have been removed.

Operation with splitting of the spermatic cord was devised by F. Torek (Med. Record, June 22, 1912). This is a much better procedure than that of Bassini as it makes a smaller cord. The spermatic vessels are separated from the vas deferens, thus dividing the cord into two parts. Instead of bringing the whole cord out at one place these two parts are brought out at two separate places, having the distance of two sutures between them. The vessels are brought out at the upper end of the wound and the vas at the middle (Fig. 1480). If preferred the vas may be brought out at its natural place in the lower extremity of the wound, and the vessels in the middle of the wound. This is a most valuable expedient, and may wisely be applied as the procedure of choice.

Operation involving transplantation of muscle is carried out by first isolating the hernial sac; then the finger is passed behind the transversalis muscle, and a rectangular flap of muscle is cut out about 5 cm. (2 inches) wide and 7.5 cm. (3 inches) long. The flap is left attached externally. The free inner end which should include some of the sheath of the rectus is swung downward and sewed to the spine of the pubes and Poupart's ligament. This operation is sometimes useful in large inguinal hernia.

Splitting off the outer part of the rectus muscle, swinging it outward and attaching it to Poupart's ligament and the pubic spine, may also be done in these cases.

Operation with transplantation of periosteum is also done in large hernial defects. A piece of periosteum is taken from the front and outer side of the thigh or inner side of the tibia. Such a piece of periosteum placed flatly

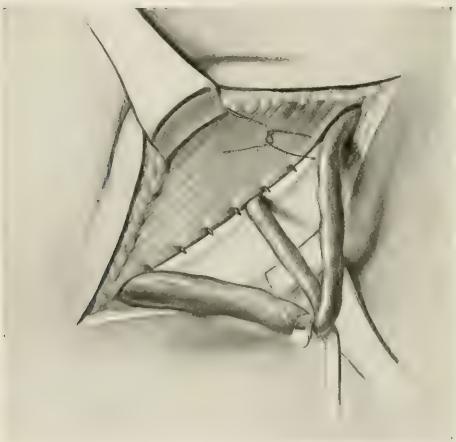


FIG. 1480.—OPERATION FOR HERNIA WITH SPLITTING OF SPERMATIC CORD INTO TWO PARTS.

in the hernial defect upon the fascia gives a firmness which is greater than that of muscle or fascia alone.

Operation with transplantation of bone may rarely be of service in hernias with large openings which are difficult to close. A piece of bone from the shaft of the tibia or a section of the eleventh rib may be used. Usually a piece of bone 4 or 5 cm. (1½ or 2 inches) long will be required. When rib is used, the resected piece should be split to double the amount of bone surface. The bone may be placed in contact with denuded pubic bone and thence caused to lie in the opening or it may be implanted directly upon the fascia in such a manner as to occlude the canal. A piece of bone shoved under Poupart's ligament below, overlapped by the conjoined tendon above, and then covered by the muscle and fascia offers an effective barrier.

This method may be utilized also in femoral and other hernias as well.

Operations for direct inguinal hernia should take into account the fact

that the opening through which the hernia emerges is internal to the epigastric artery. The artery passes externally and then above the sac. The hernia comes directly forward to the external ring through a defect of the internal oblique and transversalis fascia. Operative treatment does not offer as certain a prospect of permanent cure as is the case in oblique hernia which traverses the length of the inguinal canal. Operative treatment is demanded more urgently because mechanical retention of the hernia is much more unsatisfactory, trusses generally failing to control it. The same general principles of operation should be followed as are applied in oblique hernia. Transplantation of the cord, by the method of Torek gives good results, particularly in this form of hernia. The weakened conjoined tendon must often be replaced by transplanting the insertion of the rectus muscle.

J. C. Bloodgood has called attention to a type of direct inguinal hernia in which there is a relaxed condition of the conjoined tendon and which requires especial operative consideration. In some cases the conjoined tendon is absent. The operation requires transplantation of the rectus muscle to take the place of the conjoined tendon. W. S. Halsted modified the operation of Woelfler by turning down a flap of the anterior sheath of the rectus. It is possible in most cases to catch the lower outer border of the rectus muscle with the sutures which pass from Poupart's ligament. This draws down the rectus against the outer wall of the canal when the sutures are tied. This expedient may be applied in any case in which the inner wall of the canal is thin and weak.

Double inguinal hernia is operated upon by the same principles as single hernia. Both sides may be operated upon at one sitting, one surgeon operating on one side, another on the other side. E. S. Judd (Old Dominion Med. Jour., xvi, 1913) employed a transverse abdominal incision, 8 to 12 cm. long, from a point midway between the internal and external abdominal rings to a similar point on the other side. This incision passes through skin and superficial fascia, and exposes the aponeurosis of the external oblique. The incision is of advantage in patients who have worn trusses which have damaged the skin and other tissues below the canals; and in fat people with narrow pelves. It also permits the transplantation of rectus muscle or fascia when that expedient is needed.

Inguinal hernia in the female should be operated upon the same as in the male. The round ligament is the analog of the spermatic cord. No harm comes from compressing it, so that in closing the canal the round ligament may be neglected. In closing the canal and ring, the lowermost suture should unite to Poupart's ligament the conjoined tendon of the internal oblique and transversalis muscle and the reflected portion of the aponeurosis of the external oblique. Four or five other sutures unite to Poupart's ligament the internal oblique and external oblique, closing the canal. The closure of the aponeurosis is the same as for the male.

Interparietal hernia, in which the sac is developed between the layers of tissue of the inguinal region, should be treated by radical operation. There will usually be found two sacs, or a bilocular sac, the posterior sac lying between the peritoneum and the transversalis fascia and the other sac usually in the inguinal canal. In other cases the upper sac lies beneath the external oblique muscle. In operating it will be found that the two sacs communicate with the general peritoneal cavity by a single opening. The operation is the same as for inguinal hernia.

Interstitial hernia is similar to the above, but in most cases undescended testicle is present and the sac lies under the aponeurosis of the external oblique. In the inguinosuperficial, it lies under the skin. The treatment of

this condition is the same as that for undescended testicle with hernia. The sac is cut off, high up. The lower part of the sac is cut off, leaving enough to cover the testis, and sewed together to make a tunica vaginalis. The cord is stripped of unnecessary tissue and the testicle implanted at the bottom of the scrotum. The rest of the operation is as described above for inguinal hernia.

Inguinoperineal hernia, with maldescent of the testicle into the perineum, is treated by excision of the sac, the formation of a new tunica vaginalis, anchoring the testicle in the scrotum, and closing the canal as for inguinal hernia.

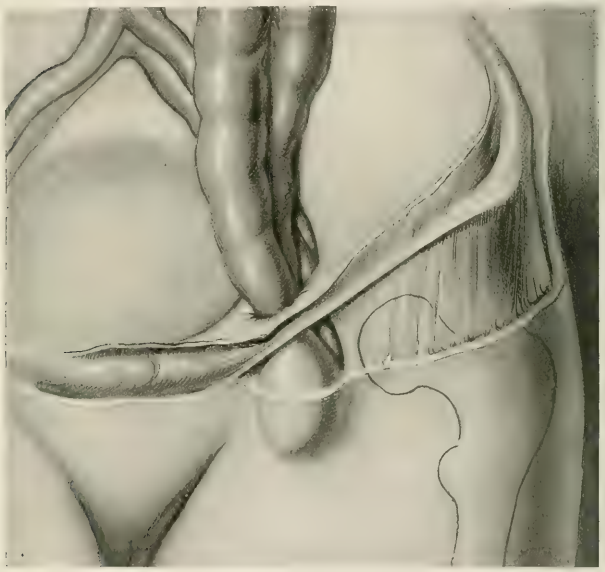


FIG. 1480*a*.—FEMORAL HERNIA.
Showing surgical problem involved. The herniated bowel passes down to the inner side of the femoral vessels.

Operations for the Radical Cure of Femoral Hernia.—In most cases the protrusion is through the femoral canal on the inner side of the femoral vein (Fig. 1480*a*). An oblique incision is made parallel with Poupart's ligament and just below it and having the inner end of the incision crossing the middle of the hernial tumor. The incision need not be as long as for inguinal hernia. The hernia should be reduced if possible. The sac is exposed and isolated, and drawn well down. A most important step is the removal of every bit of fatty tissue in the opening. The removal of this fat is facilitated by drawing down the sac. The sac should then be opened to be sure that it is empty. Adherent omentum should be freed, ligated

and cut away. The anterior border of the ring should be retracted strongly upward to expose the neck of the sac. It should be caught high up with a needle bearing a catgut ligature. The ligature should be tied around the neck of the sac as the ring is retracted and the sac drawn down. The sac is cut away. The two ends of the ligature are left long, and each carried by a needle is passed through the anterior wall of the canal emerging through Poupart's ligament and tied beneath the skin. All trace of the funicular process is thus removed. A curved needle, armed with chromic catgut, is then introduced from before backward through the inner extremity of Poupart's ligament, piercing the wall of the canal. As it appears in the canal it is grasped and carried as a purse-string suture high up around the inside of the

FIG. 1481.—OPERATION FOR FEMORAL HERNIA.
The suture, closing the canal, is applied.

canal. It picks up the pectineal fascia and muscle on the inner wall, then the layer of deep fascia in front of the femoral vessels, then passes forward through the anterior wall of the canal, and emerges through Poupart's ligament about 1 cm. ($\frac{1}{3}$ inch) from the point of entrance (Fig. 1481). The two ends are tied, effectively closing the canal. The superficial fascia and skin are closed with a subcuticular suture and a snug spica bandage, reinforced with adhesive plaster, is applied. The patient is kept quietly in bed for two weeks, as after operations for inguinal hernia. A fresh dressing is applied at the end of the first week. At the end of two weeks the patient is allowed to sit up, and to walk on the seventeenth day.

The *treatment of femoral hernia through the inguinal canal* is practised by some surgeons. By this route, the hernia is approached from behind (Fig. 1482), the sac is drawn out of the canal and cut off, the canal closed, and then the inguinal canal sutured. This approach is through the same in-

cision as that which is used for inguinal hernia. The operation takes longer than the femoral approach, possesses slightly more hazard, but more surely guarantees a cure.

The sac should be drawn out of the canal, tied and amputated. The entrance to the canal should be closed from above (Fig. 1483).

Umbilical Hernia.—*Operative treatment* of umbilical hernia in the adult is a more difficult procedure than the treatment of inguinal hernia. Reasons for this are that the hernia develops most commonly in fat women who have borne children, the sac is lined with adherent omentum, and is prone to develop pouches and partitions dividing it into many complicated compartments. The prevention of these large hernias is a surgical duty.

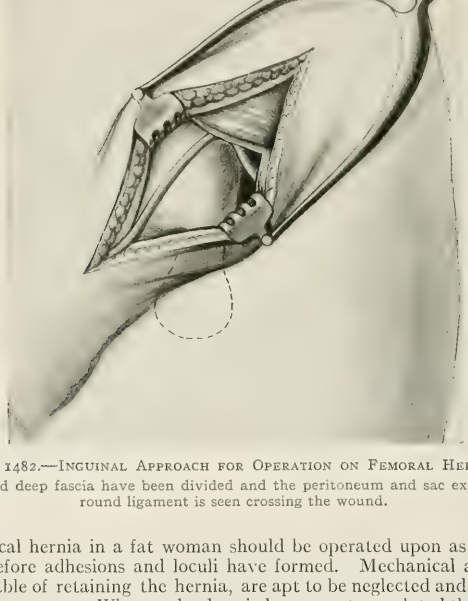


FIG. 1482.—INGUINAL APPROACH FOR OPERATION ON FEMORAL HERNIA.
The skin and deep fascia have been divided and the peritoneum and sac exposed. The round ligament is seen crossing the wound.

An umbilical hernia in a fat woman should be operated upon as soon as it appears before adhesions and loculi have formed. Mechanical appliances, while capable of retaining the hernia, are apt to be neglected and the hernia allowed to progress. When such a hernia becomes strangulated the hazard is so enormously increased that radical cure is indicated in all cases before this accident has occurred.

The *operation for small umbilical hernia* should begin with an elliptic incision about the hernia. The incision passes back through the skin and superficial fascia, and the dissection is then carried inward to the base of the hernia. Here the sac is incised. This incision is carried around the lower part of the hernia, and through all of its layers. Some of the wall of the hernia is left behind to be used for closing the defect. After division of

the peritoneum the skin and sac connected with it are lifted forward. Adherent omentum is dissected free and returned to the abdomen or, if damaged, ligated and removed. The ring is then incised above and below in the median line so as to make a longitudinal opening. The edges of the fascia are trimmed and united in such a manner that one overlaps the other after the principle employed in the suture of the aponeurosis in inguinal hernia (page 28). This overlapping may include all of the fascial layers and peritoneum between the two recti muscles.

A longer and neater, but no more effective. operation consists in splitting free the peritoneum and suturing it separately, and then proceeding with the overlapping of the fascia external to the peritoneal cavity. In very small

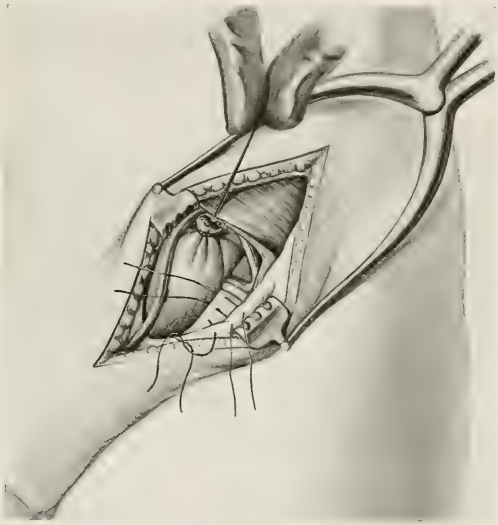


FIG. 1483.—CLOSURE OF FEMORAL CANAL FROM WITHIN THE ABDOMEN.
The sac has been tied and amputated. Sutures for closing femoral canal have been placed and are ready to be tied.

hernia no overlapping of the fascia need be done; it suffices to freshen the edges of the wound and suture them, layer to layer, just as for closure of a median wound for abdominal section.

The *purse-string operation* for small hernias may be done with absorbable ligature, silk, linen, rubber elastic, or silver wire. The ligature is passed around the base of the hernia under the skin with a curved needle. The hernia is then reduced and held with the finger while the ligature is tied.

If a rubber cord is used its two ends are held together by being tied with a ligature. The ends are left projecting from the skin opening; and after about two weeks the rubber cord comes away.

When wire is used it is twisted tightly, cut short and left buried. Absorbable ligatures are left buried. Silk or linen should have the ends exposed,

be left in a bow knot, and untied and removed at the end of three weeks. Iodin will keep the wound sterile. These operations with nonabsorbable materials are not applicable to larger hernias. They are not desirable in any case.

The *treatment of large umbilical hernia* is less simple. An elliptic incision, with its long axis in the median line, should be made in such a way as to permit removal of all the skin and superficial fascia to provide for later closure of the wound without tension or redundancy. The base of the sac is preserved if it contains thick fascia. If the ring is not large none of the sac need be saved. The sac, with its coverings and adherent contents, is lifted forward. Adherent and disorganized omentum is tied off; intestine is returned to the abdomen; and the ellipse of skin and sac is removed.

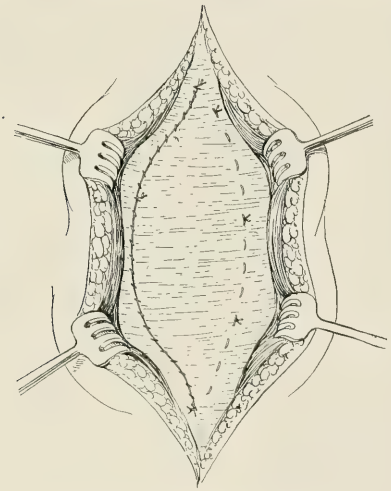


FIG. 1484.—OPERATION FOR UMBILICAL HERNIA.
Showing overlapping of transversalis flaps.

A flat pad holds back the abdominal contents. The stump of the sac is then split free from the continuation of the anterior sheaths of the recti muscles by an incision just outside of the ring, leaving the base of the sac connected with the posterior leaf of the median conjoined fascia. This consists of the continuation of the posterior sheath of the rectus, transversalis fascia, and peritoneum. The dissection is carried outward as far as the recti muscles. It should also be continued above and below the ring for a short distance. The edges of the posterior fascia-peritoneum flaps should then be trimmed evenly, the recti muscles retracted outward, and an overlapping suture of the flaps made.

The flap that is drawn into the abdomen and applied to the peritoneal surface of the anterior abdominal wall should be trimmed so that the peritoneal edge slightly overhangs the fascia, and it should be sutured in place

by an over-and-over stitch of chromic catgut crossing its free edge. The anterior flap is carried across to the other side and sutured behind the rectus to the anterior surface of its posterior sheath (Fig. 1484).

The anterior sheaths of the recti are overlapped in the same manner in front of the muscles. If there is not enough tissue they may be united edge-to-edge in the median line. The superficial fascia and skin are then sutured.

If there is enough fascia a neater piece of work can be done by cutting away the whole sac and the ring. In large hernias this is rarely possible, and some of the wall of the sac must be saved. In some cases it is possible to separate the peritoneum from the transversalis fascia and suture it separately, thus making the overlapping flaps entirely extraperitoneal.

If the posterior sheath of the rectus and the transversalis are very thin, the flaps need not be split to expose the bellies of the recti, but simply two flaps made, one from either side.

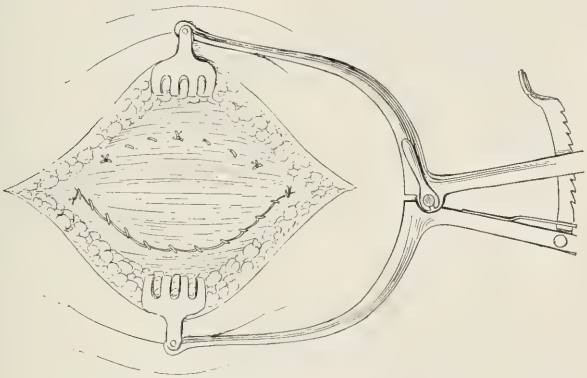


FIG. 1485.—TRANSVERSE OVERLYING FLAP OPERATION FOR UMBILICAL HERNIA.

If the opening is very large, and the fascia which has been saved is inadequate for the closure, an elliptic incision may be made on either side through the anterior sheaths of the recti muscles, and that part of the sheath lying between this incision and the ring dissected inward and left attached to the ring thus connecting it with the posterior sheath. When this is done, flaps are secured for use posterior to the plane of the rectus but no anterior flaps are to be had.

When, on account of tension, continuous suture seems undesirable, interrupted sutures should be used.

The *transverse flap operation*, used and described by Mayo (Keen's Surgery, Vol. IV, page 89) consists in excision of skin, fascia and omentum if adherent, by a transverse elliptic incision. An incision is then carried outward from either side of the ring to the rectus muscle. The lower flap is then carried up behind the anterior abdominal wall and fixed against its peritoneal surface by mattress sutures. The upper flap is sutured below in front of the fascia (Fig. 1485).

The *double sliding-flap operation* of F. G. DuBose (Surg., Gyn. and

Obst., xxi, 1915, page 771) is applicable to the smaller type of hernia or to hernia with a small ring. A transverse skin incision is made. The sac is amputated and the stump closed by a purse-string suture. Two lateral flaps of fascia are then mobilized by horizontal parallel incisions (Fig. 1486).

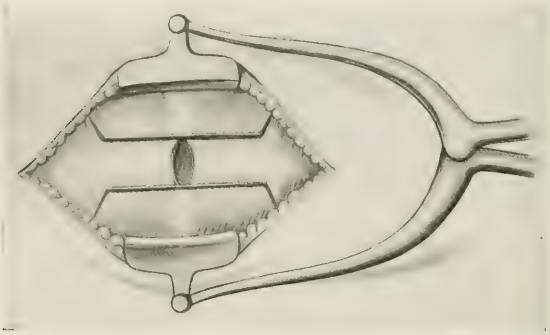


Fig. 1486.—Double Sliding-flap Operation for Umbilical Hernia.
The hernia has been reduced and the sac removed. The flaps of fascia have been marked out and cut free.

These are slid inward and their ends united in the median line (Fig. 1487). The upper and lower flaps of fascia are then drawn together and united over the lateral flaps (Fig. 1488).

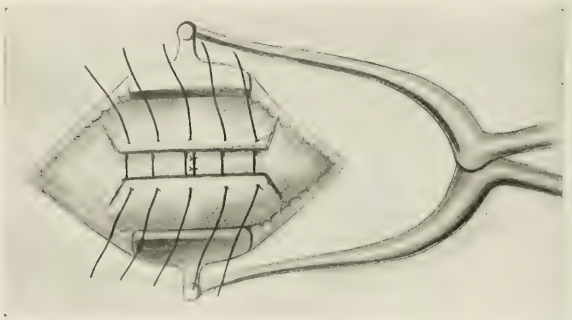


Fig. 1487.—Double Sliding-flap Operation for Umbilical Hernia.
The deeper flaps have been united. The upper and lower flaps are ready for apposition.

The operation by a *purse-string suture of wire*, devised by Lexer, and used with excellent results by my late associate Carl Fulda, is performed with as much expedition as any of the above procedures. After reduction of the hernia, and removal of the sac, a piece of silver wire having one end sharpened to be used as a needle is passed in and out through the transversalis fascia

around the opening, as a purse-string. The peritoneum is not penetrated, although if haste is necessary there is no reason why it need not be. The wire, having been passed around the opening, is then tightly drawn up till the opening is obliterated. The ends are twisted together and cut short. The skin wound is closed, burying the wire, which is left permanently.

This operation is useful in cases of small hernia and in cases in which haste is necessary. But it is not to be considered as being so effective or desirable as the operations with flaps of fascia.

Hernia of the umbilical cord, a rare form of congenital hernia, may be cured by careful cleansing, maintaining cleanliness, and applying pressure by a pad held by a strip of adhesive plaster encircling the abdomen. If the hernia is large, the cord should be cut away as far as the peritoneum; the edges of the umbilical opening should be freshened and sutured, and tension relieved by adhesive plaster. Coley believes the second or third day is the best time for operation.

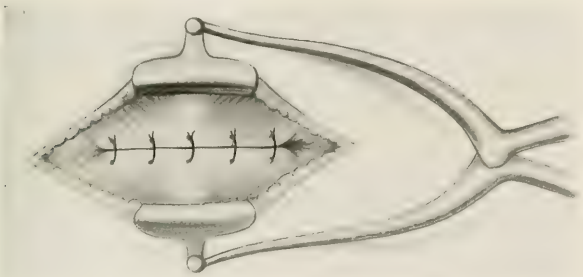


FIG. 1488.—DOUBLE SLIDING-FLAP OPERATION FOR UMBILICAL HERNIA. Flaps of fascia sutured.

Obturator Hernia.—Hernia escaping through the upper part of the obturator opening usually lies to the inner side of the obturator vessels. It should be approached by an incision internal to the femoral vessels at the femoral opening. Division of the ring should be made in any direction but outward. The sac should be removed and the opening closed with chromic catgut or tendon. If resection of bowel is required, it will usually be found most expedient to open the abdomen above the pelvis. At the same time this is done the hernial opening may be closed from the inside of the pelvis.

The tendency to recurrence of this hernia is very great, and upon this ground surgeons who have had experience with its treatment are now advising operation within the pelvis as the only assured means of accomplishing a radical cure. Schwartzschild (Deutsche Zeitschrift für Chir., September, 1904) following the suggestion of Trendelenburg and Kraske, chiseled from the posterior side of the pubic bone and its descending ramus a flap of bone and periosteum and placed it in the hernial opening, suturing over it the fascia and muscle. Unfortunately most of these hernias are not recognized, or have been regarded as intestinal obstruction of obscure origin.

Sciatic Hernia.—This rare hernia, through either the greater or lesser sciatic foramen, is best operated upon by the combined external and internal method. An attempt at reduction by operative means from without should

be made. The location of the incision must depend upon the location of the tumor, which varies as the hernia escapes above or below the pyriformis muscle. Having reduced the hernia, a radical cure cannot be expected unless the opening is closed inside the pelvis. So little experience with this hernia is recorded that there is no approved procedure. Armed with a clear picture of the anatomy of the parts, the surgeon should attempt closure of the opening by means of suture of fascia without damage to the sciatic nerve. Strangulation, which is the usual complication in these hernias, should be treated by operation within the abdomen and pelvis.

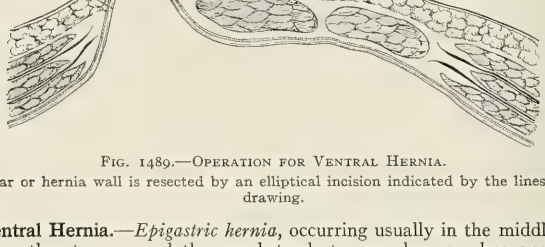


FIG. 1489.—OPERATION FOR VENTRAL HERNIA.
The scar or hernia wall is resected by an elliptical incision indicated by the lines in the drawing.

Ventral Hernia.—*Epigastric hernia,* occurring usually in the middle line between the sternum and the navel, tends to grow larger unless cured by operation. Radi al treatment is rarely urgent because the hernia is not prone to be serious while it remains small. The small hernia usually contains only omentum, and in addition to this the tumor is made up largely of fat outside the sac. Mechanical appliances are of little value. The only effective treatment consists in operation similar to that described for umbilical hernia. Overlapping flaps should be used. Whether the flaps shall lie vertically or transversely should depend upon the shape of the opening.

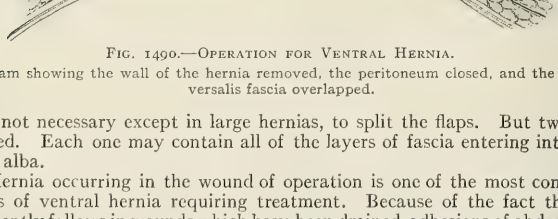


FIG. 1490.—OPERATION FOR VENTRAL HERNIA.
Diagram showing the wall of the hernia removed, the peritoneum closed, and the transversalis fascia overlapped.

It is not necessary except in large hernias, to split the flaps. But two are needed. Each one may contain all of the layers of fascia entering into the linea alba.

Hernia occurring in the wound of operation is one of the most common forms of ventral hernia requiring treatment. Because of the fact that it frequently follows in wounds which have been drained, adhesions of abdominal viscera to the scar must be looked for. The treatment in general is the same as for ventral hernia. If it is small, a simple resection of the

scar is called for (Fig. 1489). Then two planes of fascia should be discovered; they should be split apart, and two flaps overlapped and sutured. The peritoneum should have been sutured separately (Fig. 1490).

If still more reinforcement is needed in these hernias a flap of fascia may be turned over from the anterior sheath of the rectus muscle. Such a flap may be taken from either side. Or a free piece of fascia may be transplanted from the outer side of the thigh.

Hernia through the linea semilunaris should be treated the same as the above.

Lumbar Hernia.—This hernia is so rare that few have been treated. It can be controlled by a truss, but operation has proved most satisfactory.

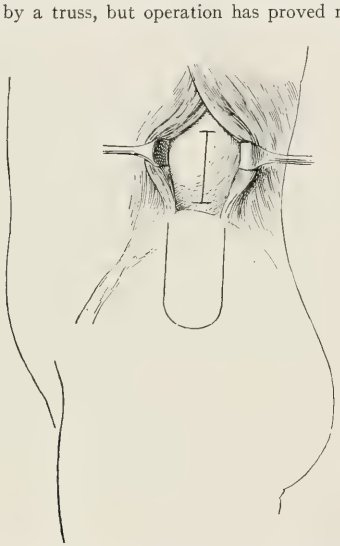


FIG. 1491.—DIAGRAM OF OPERATION FOR LUMBAR HERNIA.

The incision is made through the hernial sac, which consists of transversalis fascia and peritoneum. The incision may be crossed at either end by a short transverse incision to permit better overlapping of the flaps. To strengthen the wound, a flap of fascia is turned up from below.

The operation performed by C. N. Dowd (Annals of Surgery, February, 1907) consists first in turning up a flap of fascia lata and the aponeurosis overlying the gluteus maximus and medius. This flap covers the lower part of the triangular opening. The opening is still further narrowed by sewing together its posterior and anterior sides composed respectively of the latissimus dorsi muscle and the external oblique muscle. To cover the suture lines a flap of aponeurosis of the latissimus dorsi is turned forward.

A less complicated operation would, perhaps, prove quite as effective, based upon the principle of the overlapping flaps of fascia. Such flaps could be secured from the transversalis fascia. If the hernia is not large, the peritoneum need not be opened. But if there is much bulging the

abdomen should be opened by a vertical incision in the middle of the sac. This should be made through the transversalis fascia and peritoneum as the muscles on either side of the opening are retracted (Fig. 1491). If necessary, the vertical incision may be joined at either end by a short transverse incision to permit better overlapping of the flaps. The flaps on either side are overlapped, and each one sutured with chromic catgut. The posterior flap is sutured inside the abdomen against the peritoneum of the lateral abdominal wall as already described for umbilical hernia. The

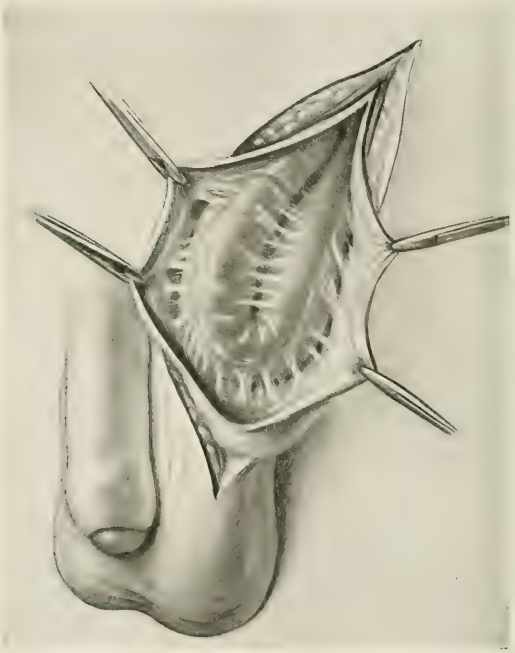


FIG. 1492.—OPERATION FOR ADHERENT HERNIA OF THE LARGE INTESTINE.
The sac has been incised. The bowel is seen adherent to its inner surface.

external oblique and latissimus dorsi should then be sutured together to close the muscular opening. If this opening is large a flap of fascia should first be turned into it from below the crest of the ileum, and the muscles sutured over it. Such a flap would be cut from the aponeurosis overlying the gluteus medius and gluteus maximus muscles, and left attached at its base above.

Pelvic Hernia.—This rare form of hernia, usually appearing through the pelvic floor, must be treated on the general principles already laid down.

If strangulation has occurred, operation within the abdomen should be done. The closure of the opening must be effected by plastic operation similar to that employed for other pelvic operations. Complicating prolapse of the rectum or uterus should be treated by the measures applicable to those conditions. Thomas advised inverting the sac and suturing the inverted apex to the abdominal wall within the abdomen.

Sliding Hernia of the Large Intestine (Adherent Hernia).—This not uncommon condition requires, first, that the neck of the sac shall be well

FIG. 1493.—OPERATION FOR ADHERENT HERNIA.

The sac is being sewed inside out with the bowel attached, providing a peritoneal surface over the intestinal loop to be returned to the abdomen.

exposed and the whole sac isolated. The ordinary hernia incision is not sufficient. There should be added to it an extension of the incision upward which converts the operation into an abdominal section. Having done this, the contents of the sac are freely exposed by incising the sac midway between the two loops of intestine (Fig. 1492). The free edges of the sac are then carried back of the bowel-loop and sewed together. Thus the sac is used to cover the raw surface which must otherwise be returned to the peritoneum

(Fig. 1493). The loop of intestine may now be returned. If necessary it may be anchored to the posterior wall of the abdomen. The great opening should be closed as for abdominal section and hernia. This is practically the operation devised by J. L. Ransohoff (Annals of Surg., Vol. 56, p. 313).

Diaphragmatic Hernia.—This hernia is so rare that no uniformity of treatment is accepted. Whether due to a congenital cleft of the diaphragm or to traumatic injury the best route of approach must vary with the nature of the rupture. If strangulation, requiring resection, is present, obviously approach through the abdomen is better. In non-strangulated cases it is the opinion of surgeons who have operated upon these hernias that the transpleural route is better. Rydygier advised making an osteoplastic flap, cutting the ribs and hinging the flap anteriorly at the sternocostal articulation (see Thoracoplasty, Vol. II, p. 410 to 463). Suture of the hernial opening in the diaphragm is difficult if the opening is large. Even small openings are sutured with difficulty. It has been suggested that the stomach be sewed across the opening to act as a closing barrier. On the right side the liver may be used. Better than either of these is a transplanted flap of fascia.

Hernia following stab wound should be operated upon early, as the tendency is for more and more viscera to find their way into the thorax.

Internal Hernia (Retroperitoneal, concealed hernia).—*Duodenal hernia*, occurring in the *inferior duodenal fossa*, the *paraduodenal fossa*, the *mesentericoparietal fossa* and the *mesocolic fossa* are classified as *duodenal hernia*. Most cases have been on the left side of the duodenum. If seen early enough the loop of bowel, even when strangulated, can be drawn out of the sac by means of manipulation and gentle traction. The closure of the opening has usually been accomplished by a peritoneal suture. This may be applied as a purse-string beginning as far back in the sac as possible and working forward toward the entrance.

If the contents of the sac cannot be disengaged the problem is a difficult one. In the duodenal hernia the ring cannot well be enlarged by incision because it is bounded in front by important vessels. In right duodenal hernia the superior mesenteric artery, and in left duodenal hernia the inferior mesenteric vein and the left colic artery bound the front of the opening. In fact, these vessels constitute the loop under which the hernia passes. It may be possible to cut some part of the ring without injury to the vessels, but probably in most cases it is not possible to make such an incision of sufficient extent to be of service. When reduction cannot be accomplished by ordinary means, it is recommended by Moynihan that the sac be opened by incision through the two layers of peritoneum on the other side of the vessels. Usually it will be found that reduction has been hindered because of volvulus of the loop of intestine within the sac, and when the twist is relieved reduction becomes possible.

If reduction cannot be accomplished the bowel should be incised and emptied of its contents by means of a tube held by a purse-string suture. When emptied, and, if necessary, washed out, reduction should not be difficult. After such a procedure the hernial opening into the sac should be closed by a purse-string suture, and the interior of the sac drained through the incision opening.

Pericecal hernia, occurring in any of the several fossæ about the cecum, is treated the same as duodenal hernia. The vessels about the opening are not of such great importance; so that, the diagnosis having been made, the problem of treatment is not difficult.

Hernia through the foramen of Winslow should be exposed by median incision above the umbilicus, and made sufficiently long to give free access. Careful manipulation and traction should reduce the hernia. If this fails, the enlargement of the ring may be attempted by incision of the anterior leaf of the gastrohepatic omentum. This incision begins at the upper border of the first part of the duodenum and divides the gastrohepatic ligament between the pylorus and liver. Moynihan advises entering the lesser peritoneal cavity by incising the gastrohepatic omentum above the stomach or the gastrocolic omentum below it, and reducing the size of the coil of intestine by untwisting it if twisted or by incising the bowel and emptying it. This procedure permits reduction of the hernia without enlarging the foramen of Winslow.

Hernia of Special Organs.—*Hernia of the cecum and appendix*, when uncomplicated by inflammation, requires no special treatment. When appendicitis or typhlitis exists in the sac the disease should be treated the same as usual. In cases in which removal of the appendix is called for the ordinary hernial opening may not give adequate room; in such cases the opening should be enlarged—in inguinal hernia by splitting upward and outward the fibers of the external oblique and its aponeurosis. This allows of radical closure of the wound. The immediate closure or the drainage of the site of inflammation should be governed by the rules applicable to the treatment of the particular infection. If no drainage is required, the radical cure is proceeded with; if drainage is used, the closure of the opening is deferred until drainage is no longer necessary. A radical closure should be done. To allow such a wound to heal by granulation without further operation is to invite recurrence of hernia.

Hernia of the bladder should always be looked for in operating for large inguinal ruptures and sliding hernias. The bladder may be injured by traction upon the sac and placing the ligature in the bladder. If the bladder is suspected of being involved in a hernia, the administration of methylene blue for a day before operation will permit of the ready recognition of a penetrating wound. A mass of fatty tissue with large veins appearing at the external ring usually means bladder. When the bladder has been opened by accidental incision, the opening should be closed by two layers of sutures external to its mucous membrane, a cigarette drain should be left in the hernia wound for at least thirty-six hours, and a catheter for constant drainage should be fixed in the urethra. Accidental puncture of the bladder by a needle should be treated in precisely the same manner as above described for incision of the bladder.

Hernia of the uterus, Fallopian tube, and ovary, one or all, should be treated by radical operation for the cure of the hernia as soon as the diagnosis is made. Hernia of the uterus soon becomes irreducible, and the supervention of pregnancy adds a serious complication. Cesarean section is necessary if the pregnancy is far advanced.

Hernia of omentum is most common, as omentum may be found with or without intestine in most hernias. When the omentum has but recently entered the sac, and is not adherent, edematous, or injured, it may be reduced and returned to the abdomen. This can rarely be done. Usually it is found thickened, inflamed, and matted together. Such omentum should be liberated, drawn down, tied off through sound omental tissue and the diseased end cut off. Omentum which is adherent to the sac or contents, after it has been stripped off will naturally become adherent in the abdomen if it is returned; therefore the part contained in the sac should be tied off and removed.

No large mass of omentum should be included in one ligature. The ligatures should be of fine catgut, and each one should include a mass not thicker than 5 mm. ($\frac{3}{16}$ inch). The omentum should be cut, leaving enough stump to prevent the ligatures slipping.

Hernia of practically every one of *the abdominal organs* occurs, and requires treatment according to its location and the character of the organ involved.

Operations for Hernia in Two Stages.—It sometimes occurs that because of the presence of infection requiring drainage, because of the necessity for making an artificial anus, or because of the condition of the patient, an operation for hernia must remain uncompleted. A radical cure cannot be regarded as having been effected unless the hernial opening has been closed by one of the methods described above for that purpose. Such a wound that has healed by granulation cannot be regarded as a permanent cure, and recurrence of the hernia may be expected. This is because of the poor vitality and the yielding tendency of scar tissue. For this reason, as soon as possible and when aseptic conditions can be secured, the operation should be completed. Even when granulations are present, sterilization can be secured by iodin or phenol. The parts should be exposed and identified and the concluding steps of the operation taken.

RECTUM AND ANUS

Anatomy.—The rectum begins above at the sigmoid colon which passes obliquely downward, backward and to the right, from the left pelvic brim. It begins at the top of the second sacral vertebra. (Some anatomists classify as first part of the rectum the part of the bowel between the pelvic brim and third sacral vertebra.) The rectum passes downward to the right of the middle line, thence back to the middle line at the sacrococcygeal joint, thence downward and forward to the apex of the prostate gland which is about 2.5 cm. (1 inch) anterior to the sacrococcygeal joint. This is called the upper segment. From this point, it passes downward and backward to the anus. This is called the lower segment.

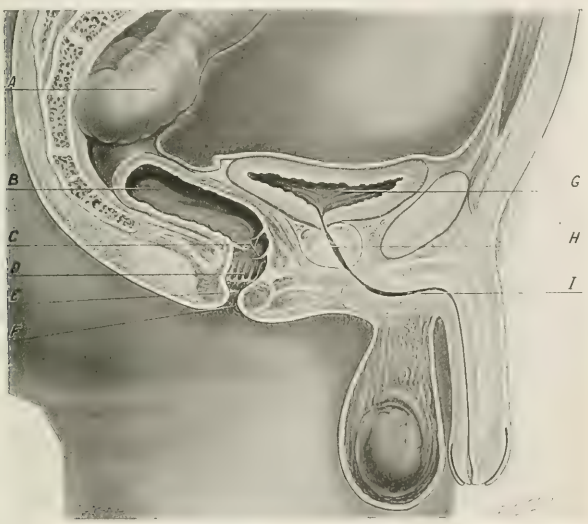


Fig. 1494.—The Rectum.

Anatomic relations: *A*, Sigmoid; *B*, rectum; *C*, valves of rectum; *D*, crypts and columns of Morgagni; *E*, sphincteric white line; *F*, anus; *G*, urinary bladder; *H*, prostate gland; *I*, urethra.

The upper segment of the rectum is about 9 to 10 cm. (3½ to 4 inches) long; the lower segment is about 5 cm. (2 inches) long.

The upper part is partly covered by peritoneum. About 2.5 cm. (1 inch) above the prostate or at the lower part of the upper one-fifth of the vagina the peritoneum is reflected forward from the front of the rectum to the posterior surface of the bladder in the male, or to the posterior surface of the upper fifth of the vagina in the female. On the posterior surface of the rectum the peritoneum ends about 12.5 cm. (5 inches) above the anus.

The *upper segment* in the male has in front of it the rectovesical pouch, small bowel, trigonal part of bladder, vesiculæ seminales, vasa deferentia, and the prostate gland at its lower part. In the female, in front is the rectovaginal pouch usually containing small intestine. Behind is the sacrum, coccyx and middle sacral vessels (Fig. 1494).

The *lower segment*, or anal canal, has no peritoneal covering. It is surrounded by sphincter muscle. In front is the bulb and membranous part of the urethra in the male, and the perineal body in the female. Behind are the coccygei muscles, and laterally are the areolar tissue of the ischiorectal spaces and the levatores ani muscles.

The *anus* is surrounded by the internal sphincter, levatores ani muscles, and external sphincter.

The *blood supply* of the rectum is through the inferior mesenteric (superior hemorrhoidal), middle hemorrhoidal of the internal iliac, inferior hemorrhoidal of the internal pudic, sacra media of the abdominal aorta, sciatic of the internal iliac, and from the vaginal branches of the internal iliac. The veins are chiefly the superior hemorrhoidal of the inferior mesenteric which empty into the portal system. Some venous return is into the inferior vena cava, by systemic veins which anastomose around the rectum with the portal radicals.

The *lymphatics* empty into the anterior sacral and inguinal lymph nodes.

The *nerves* of the rectum are from the sacral plexus of cerebrospinal nerves, also from the sympathetic system.

FIG. 1495.—PERINEAL POSITION.

The *mucous membrane* of the rectum is very vascular. The submucous coat is of loose areolar tissue; and when the rectum is not dilated the mucous lining is thrown into folds both transversely and longitudinally. The anal portion is thrown into deep longitudinal folds forming sulci and pits capable to retaining foreign material.

The *valves* of the rectum are folds of mucous membrane placed transversely. There are three important valves. They are crescent-shaped. The lowest lies on the anterior wall about 5 cm. (2 inches) above the anus. Another is opposite it in the sacral hollow. The uppermost is at the sigmoid junction.

The *musculature* is similar to that of the rest of the alimentary canal. The lower sphincter is located at the anal orifice and lies beneath the skin-mucosa junction. The upper sphincter is broader, and embraces the lower segment. The rectum has the power to empty itself, independent of the action of the abdominal muscles.

Preparations for Operation. It is desirable that the bowel should be well cleaned out before operations on the rectum. This should be accom-

plished by well-timed catharsis, irrigation and dieting. The practice of giving a cathartic twelve hours before operation and colonic irrigation two hours before results in a dribbling of water and feces during the operation. If the patient has been having regular bowel movements, it is often better for the ordinary operation, to leave him alone, and give a small, low, medicated enema (see Vol. II, page 620) an hour before the operation.

It is rarely worth while to give time to building up a patient with anorectal disease, as the rundown condition is most apt to be due to the disease, and the general health is best restored by its immediate cure.

In most operations, shaving of the anal region is not necessary. The most useful position for anorectal work is the so-called elevated perineal position (Fig. 1495). The sacrum should rest on a sand-bag at the extreme lower end of the table, and the hips and knees should be flexed. The knee-chest position is more useful for examination than for operation. The prone flexed thigh position on an angular table is useful in rectal excisions. The special rectal instruments are specula and proctoscopes (Figs. 1496 and 1497). These are made in many sizes and forms (Fig. 1498).

Fig. 1496.—Open Frame Rectal Speculum.

For operations in the anorectal region local *anesthesia* can be used in the majority of cases. Operations for small hemorrhoids, simple fistula, fissure, ulcers and polyps, can be performed under anesthesia produced by cocain, novocain or their substitutes. General anesthesia is to be preferred in cases of large or ordinary hemorrhoids, in deep or complicated fistula, and in fissure and ulcer, which are complicated by other diseases.

Proctoclysis (Coproclysis).—Water introduced into the rectum in quantities not large enough to distend the bowel, is absorbed and added to the

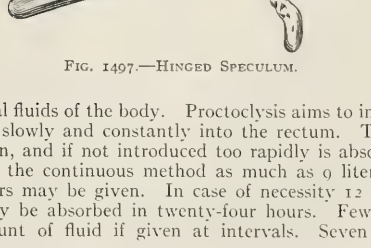


Fig. 1497.—Hinged Speculum.

blood and general fluids of the body. Proctoclysis aims to introduce a small amount of fluid slowly and constantly into the rectum. This fluid passes up into the colon, and if not introduced too rapidly is absorbed as fast as it runs in. By the continuous method as much as 9 liters (18 pints) in twenty-four hours may be given. In case of necessity 12 or 15 liters (24 or 30 pints) may be absorbed in twenty-four hours. Few patients could retain this amount of fluid if given at intervals. Seven hundred cubic

centimeters (1½ pint) every two hours is more than most patients would tolerate; yet when given continuously that amount is easily taken care of.

Proctoclysis is employed in anemia, shock, various forms of peritonitis and toxemic conditions. The flow of fluid should be nicely regulated, as it is upon this that the success of the operation depends. Moderate distention of the bowel is secured. Too great distention results in expulsion of the whole mass of fluid. The absorbing power of the colon is surprisingly great. The administration of the fluid should have been preceded by cleansing of the bowel by enema.

The most simple apparatus is a fountain syringe or can, connected with a rubber tube, ending in a tip with many openings. The tip is inserted into the rectum and fastened to the buttocks by adhesive strips so that it may not slip out. The bag or can should be suspended near the patient so that its base is about 15 cm. (6 inches) above the level of the anus. The fluid in the reservoir should be kept at a temperature of 39°C. (102°F.) by means of a

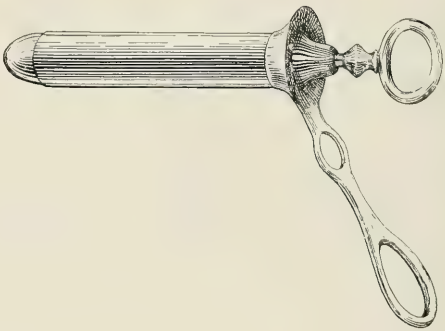


Fig. 1498.—Proctoscope.

flame, thermolyte or other apparatus. A large unobstructed tube should be used so that if the patient strains, coughs, or passes wind, the fluid can go back into the tube, and not be expelled into the bed. For this reason the caliber of the tube should not be diminished by clamps; and a tip with many openings permits a temporary backward escape of fluid when necessary. A drop attachment should be introduced in the apparatus.

Proctoclysis is continued usually for two or three days; but it may be employed longer if necessary. The most comfortable position for the patient is with the upper part of the trunk elevated (Fig. 1499). Seven or eight hundred cubic centimeters (1½ pints) of warm water are placed in the reservoir every two hours and the reservoir raised or lowered so that it takes forty-five or sixty minutes for this amount to flow into the bowel. This gives a period of rest of an hour or more every two hours. Patients tolerate this for days without complaint. If too much solution is being absorbed slight edema of the ankles, hands or face will appear after three or four days. This should be met by discontinuance of the treatment until the edema subsides; and then it may be resumed.

If the end of the rectal tube is curved it will not press against the posterior wall of the rectum. By strapping the tube to the buttock, the immobility

prevents irritation of the sphincter. The best results will be secured by not having the reservoir higher than 38 cm. (15 inches). The best results are secured by an elevation of from 10 to 18 cm. (4 to 7 inches). A glass tube should be introduced at some place in the tube in order to show the flow.

Many devices, more or less complicated, have been employed to keep the fluid warm and regulate the flow. Kemp (New York Med. Jour., Aug. 14, 1909) employed a vacuum bottle with a special attachment. Heating the fluid may also be accomplished by passing the conducting tube through a vessel of water kept heated by an electric bulb or a small flame, or by passing the tube between two hot-water bags. A reservoir with a hot-water jacket is also effective. S. E. Newman (Jour. Am. Med. Assoc., April 17, 1909) used two funnels, the upper one serving as a reservoir, the lower as a

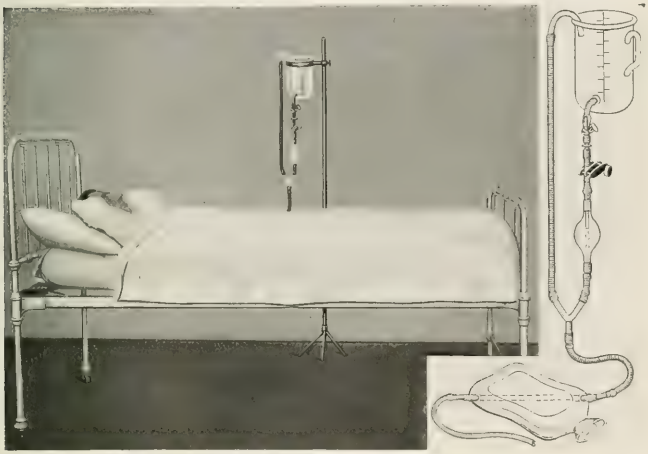


FIG. 1499.—PROCTOCLYSIS

Apparatus for the infusion of fluids into the rectum by the drop method. A hot-water bottle of special construction warms the fluid.

heating chamber (Fig. 1500). The apparatus of Elbrecht passes the fluid through a chamber capable of being heated by electricity or a lamp flame. For regulating the flow the low position of the reservoir usually suffices; but when it is desired to supply fluid drop-by-drop this can be accomplished by constricting the tube, by arranging a small supply orifice or a wick siphon. Instead of the bent rectal tube, a small soft rubber catheter is much used; also a rectal plug of hard rubber perforated by an opening through which a soft catheter is passed (Fig. 1501).

Formerly salt solution was employed. This was composed of 4 Gm. (1 dram) each of sodium chlorid and calcium chlorid in 500 c.c. (1 pint) of water. For smaller amounts this solution is desirable; but for the large amounts used in proctoclysis too much salt is taken into the system. Moreover, plain water is absorbed more rapidly than is salt solution. If salt

solution is used in large amounts albuminuria and edema are more apt to develop than when plain water is used.

To compensate for the salts which are removed from the body by the use of plain water, it is well to introduce a liter (1 quart) of salt solution at the end of the proctoclysis.

Sugar solution is useful for proctoclysis if the patient is in need of carbohydrate food or is depressed from deficient muscular tone. *Glucose* may be used in solution in water in the strength of 15 Gm. (4 drams) of sugar to

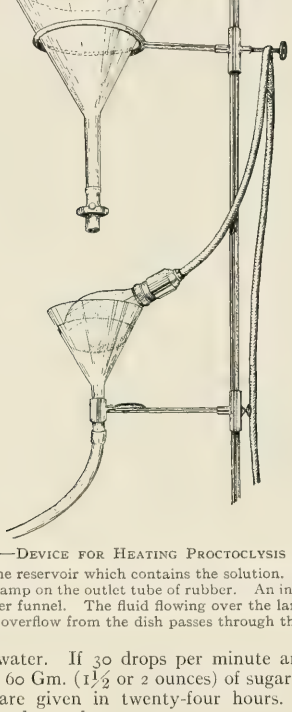


FIG. 1500.—DEVICE FOR HEATING PROCTOCLYSIS SOLUTION.

The upper funnel is the reservoir which contains the solution. The escape of the solution is regulated by the clamp on the outlet tube of rubber. An incandescent electric lamp rests in a dish in the lower funnel. The fluid flowing over the lamp and accumulating in the dish is heated. The overflow from the dish passes through the tube to the rectum.

1 liter (1 quart) of water. If 30 drops per minute are administered, the patient receives 45 or 60 Gm. (1½ or 2 ounces) of sugar, if 3 or 4 liters (3 or 4 quarts) of solution are given in twenty-four hours. In the absence of glucose *cane sugar* may be used.

Sugar solution, thus employed, not only supplies the demand for fluids but also furnishes the most essential muscle-strengthening food.

Thirst assuaged by sea water is a possibility which has developed out of the surgeon's experience with proctoclysis. M. Roberts (Brit. Med. Jour., Feb. 16, 1918) reported the experience of R. Graham who fasted during a sea voyage and injected daily 8 liters (2 gallons) of clean sea water into the rec-

tum. He drank no fluids during the first five days, and experienced no sensation of thirst until the sixth day when he drank half a glass of water. During this period he felt well, his pulse was normal, his strength was good, and his bowels moved regularly. This demonstration is important because of its possibilities in the event of *shipwreck* or other circumstances depriving the individual of access to fresh water. In the absence of a fountain syringe, apparatus may be extemporized. A bottle with its bottom removed, to act as a funnel; a piece of rubber, wooden or metallic tubing; a tobacco pipe; or a piece of rubber cloth or tarpaulin, rolled into a tube about a piece of spirally wound wire, may be used for insertion into the rectum for the purpose of introducing the sea water. A funnel may be extemporized from any of the above-mentioned materials. For lubricating purposes, grease, oil, soap, saliva or other glairy or viscid fluid may be used.

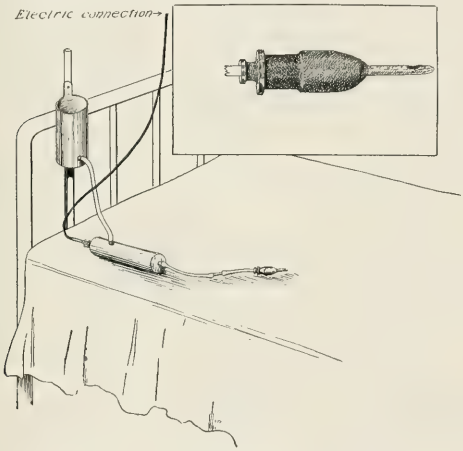


FIG. 1501.—RECTAL PLUG AND ELECTRIC HEATING DEVICE FOR PROCTOCLYSIS.
The plug with catheter is shown in insert above.

When no material for constructing a tube is at hand the individual may be placed in the exaggerated knee-chest position with the anus in the superior position; the anus may be opened by means of three or four lead pencils, pegs, or rolls of cloth of a similar size, inserted about 5 or 6 cm. (2 or 2½ inches), and salt water poured through the interstices. If no such apparatus is available two fingers may be inserted into the rectum, slightly separated, and the water poured between. If no receptacle is to be had the water may be dipped up in the hand.

An ingenious person who is alone should be able to carry out one of these technics upon himself. Where several persons are together, at least one should master the technic. The operation should be carried out with great patience and gentleness. The best possible cleanliness should be observed. Extemporized apparatus should be smooth and not permitted to cause abrasions. If the skin and mucous membrane are not wounded it is possible to teach the anal sphincter to relax under slight outward pressure. The

amount of sea water introduced should if possible be a measured quantity, so that the operation may be carried out regularly and with scientific accuracy, according to the above principles of proctoclysis. No person should go to sea without this knowledge.

Wounds and Injuries of the Rectum.—Because of loose areolar tissue about the rectum infection through the rectal wall easily spreads. The peritoneum or bladder may be wounded and infected at the same time. No wound of the rectum should be regarded as trivial. A penetrating wound of the rectum from below, through the skin and ischiorectal space, without injury of the sphincter, should be treated by dilatation of the sphincter, suture of the rectal wall if the wound is large, and drainage of the ischiorectal space. Wounds through the vagina should be sutured and the rectal sphincter dilated. Wounds of the peritoneum and rectum should be sutured, the peritoneal cavity treated as for penetrating infected wounds, and the anal sphincter dilated. A rubber tube wrapped with gauze may be passed through the sphincter into the rectum, and left to permit the escape of gas and feces, and thus relieve the rectal wall of pressure.

Wounds of the sphincter ani, where completely dividing the muscle, may be sutured at once. *Old wounds* such as follow operations for fistula, and leave *incontinence of feces*, are amenable to treatment, and a well-executed operation gives most satisfactory results. The bowel should be emptied and the sphincter dilated. The parts should be cleaned. An incision, having the scar of the old wound near its middle, should be carried about halfway round the anal orifice about 2.5 cm. (1 inch) away from it. The skin should then be dissected down toward the anus until the sphincter muscle is well exposed. The dissection should not penetrate the mucous membrane or button-hole the skin. Having exposed the sphincter, its separated ends should be sutured together with chromic catgut, and the skin flap sewed back in place. If an aseptic operation has been done union of the muscle will be secured. It is firm enough to resist tension in seven days. My own practice has been to keep these patients very quiet and to feed them on food giving a minimum amount of residue—such as albumin water, whey, broth and grape juice. A movement of the bowels is not allowed before the seventh day after the operation. If necessary, constipation may be maintained by using a few drops of tincture of opium during the first few days. A movement of the bowels before the seventh day jeopardizes the result. There is but one way to guarantee a good result and that is to make an artificial anus in the sigmoid. Usually a successful result can be secured without this.

Stretching or dilating of the sphincter ani is an operation which is employed as a preliminary to many operations on the rectum and anus. Its chief value is in relieving the rectum and anus of pressure. When the sphincter has been stretched to such a degree that it is paralyzed, gas and feces entering the rectum are not retained under pressure, a relaxed condition of the wall of the rectum is secured, and healing of wounds goes on better. In wounds or ulcers in the region of the sphincter, its paralysis by stretching is quite necessary, for the reason that if it is much in motion, relaxing and contracting, as it does in the normal state of the sphincter, healing is prevented. But what is still more important the presence of a wound or ulcer near the sphincter excites spasm of that muscle, and not only interferes with local healing but excites derangement of the whole alimentary canal.

The operation of stretching the sphincter is best done under general narcosis. The patient lies with the thighs and knees flexed. The thumbs of the operator are lubricated and introduced into the rectum, first one and

then the other. With the palms of the fingers against the outer side of the ischia, the anal orifice is gradually dilated as far as possible. To secure still greater dilatation traction may be made also forward and backward.

As a result of the operation, the fibers of the sphincter are stretched apart. The muscle remains paralyzed for two or three days, and then gradually regains its tone.

During the operation respiration is caused to be much stimulated. With each stretching the patient takes a deep breath. The anesthetist should withhold the anesthetic at such times, as a dangerously large amount of narcotic vapor may be inhaled.

The *expiratory moan* which is caused by irritation of the splanchnic nerves and is observed when the surgeon is operating in the upper abdomen, and the *inspiratory moan* which is caused by irritation of the sigmoid, rectum and sphincter ani and is observed when the surgeon is operating in those regions, may occur in a patient who is deeply anesthetized and mislead the anesthetist into giving more anesthetic. This is a reason why the anesthetist should know what the surgeon is doing and should be familiar with these phenomena.

Inflammation of the Rectum (Proctitis).—The treatment must vary with the nature of the infection. Constitutional treatment, as in all infections, is important. Locally the rectum should be kept cleansed. Irrigation twice daily with warm saline or boracic solution is to be recommended. Nitrate of silver solution (2 per cent.) swabbed on the inflamed surface through a speculum is most effective. This may be repeated every five days.

For tenesmus and pain, the irrigation may be followed by a demulcent application. This may be made by boiling 60 Gm. (2 ounces) of cornstarch or flaxseed in 1 liter (1 quart) of water. One hundred and twenty cubic centimeters (4 ounces) of this fluid, to which is added 10 drops of tincture of opium, are injected into the rectum. It should be caused to be retained by making pressure on the anus after its introduction. If the tenesmus is extreme the rectum should be irrigated; then 0.03 or 0.05 Gm. ($\frac{1}{2}$ or $\frac{3}{4}$ grain) of cocain, dissolved in 15 c.c. ($\frac{1}{2}$ ounce) of water, should be injected; and this followed by the demulcent mixture.

In severe *ulcerative proctitis* a 10 per cent. solution of silver nitrate applied a few times on a swab directly to the ulcers is effective. Or tincture of iodin, or picric acid, or nitric acid may be employed.

Rectal erosions are cured by permanganate of potash in solution, or the pure crystals may be used.

In *amebic ulceration*, the local application of nitric acid and daily irrigation of the bowel are the effective measures (see Amebic Colitis, Vol. II, page 570).

In *syphilitic proctitis*, the constitutional treatment is most important. The rectum should be kept cleansed with irrigation, and the individual ulcers should be touched with iodin. *Tubercular proctitis* should receive the general treatment of tuberculosis. The rectum should be irrigated daily. The local use of iodoform in 10 per cent. emulsion is perhaps of value. Two or three teaspoonfuls (8 or 12 c.c.) of this may be injected daily; or every five days the ulcers may be touched with tincture of iodin. The strictures arising from these two forms of proctitis are discussed elsewhere.

All forms of ulceration of the rectum are benefited by irrigation of the bowel. This is of especial importance in such conditions as are associated with similar lesions higher in the intestine. Here colonic irrigation, either through the rectum or through an artificial opening in the cecum, is often indicated.

In intractable inflammations, ulcerations or contractures, colostomy should be done to secure rest and freedom from irritation.

Ischiorectal Abscess.—When infection has invaded the perirectal areolar tissue, suppuration usually follows. But even before the tissues have broken down into an abscess the treatment is the same as for abscess. Local applications of cold or heat are of no avail in aborting this form of suppuration. There is one effective treatment, and that is free incision as soon as infection of the ischiorectal tissue is recognized.

Often an induration can be felt through the rectal wall before the cellulitis has reached the skin. I have had most happy results by incising this area through the skin under cocain anesthesia, when it was not larger than a hickory nut, introducing a drainage tube and gauze, and witnessing a subsidence of the infection, without at all involving the sphincter in the operation.

When the infection is more extensive, as it usually is when first seen by the surgeon, a free incision should be made through the skin well away from the anus. This incision is best made in an anteroposterior direction and should freely open all the infected area. Septa and trabeculæ should be divided until a single cavity is secured. The skin opening should be wider than the widest part of this cavity. If deep, several drainage tubes should be placed in its deeper parts and the rest filled with gauze packing. If not deep, gauze packing will suffice. If the infection has crossed to the other side an incision should be made there, and the two connected by a third incision.

In opening an ischiorectal abscess the mistake is to make inadequate incisions. The abscess must heal by granulations from the bottom toward the skin, and if the skin side, or mouth, of the cavity closes before the bottom is healed, a recurrence of the abscess may be expected.

If the rectal wall has been penetrated by sloughing and there is an opening connecting the rectal and the abscess cavities, a knife should be introduced through it and the sphincter below this opening divided downward and through the skin. If this is not done a fistula in ano will remain to be treated.

In all but small areas of infection it is well to precede the operation by stretching the sphincter in order to set the region of operation at rest.

The wound should be kept clean. It should be packed with antiseptic gauze at least once daily and always after defecation. This packing is most important. If neglected, the superficial parts are apt to fall together and unite leaving the nucleus of an abscess behind. The skin opening must be kept dilated by the packing until the excavation has closed by filling with granulation tissue from the bottom.

In old abscesses with dense scar tissue in their walls, the scar tissue should be dissected out. If this is not done, it should at least be treated by multiple incisions.

In cases of perforation, if a large abscess cavity has become lined with granulations, a plastic operation closing the opening in the bowel may be undertaken, and the patient spared the inconvenience of having the sphincter divided as described above.

Fistula in the Anal Region.—These fistulas result usually from abscesses which have not received adequate treatment. Radical operation for fistula should not be done if cellulitis or acute infection is present; drainage is then the important thing. Operation for the cure of the fistula should be done after acute infection has subsided. Irrigation and hot baths may hasten the cure.

Whether the fistula communicates with the anal canal or not, the

most satisfactory treatment is operation, preceded by stretching the sphincter. If no communication with the bowel is found, it is desirable nevertheless to paralyze still further the external sphincter by dividing it. This is done by passing a probe into the fistula and then causing it to enter the rectum between the two sphincters. The bridge of tissue below the probe is then divided. When a *fistula in ano* exists, it will usually be found that the opening into the bowel is between the two sphincters. The probe should be passed through this opening, and the bridge of tissue divided (Fig. 1502). Only the lower sphincter need be cut.

It is important that every pocket should be laid open. Careful examination should be made, and recesses freely incised so that the skin opening

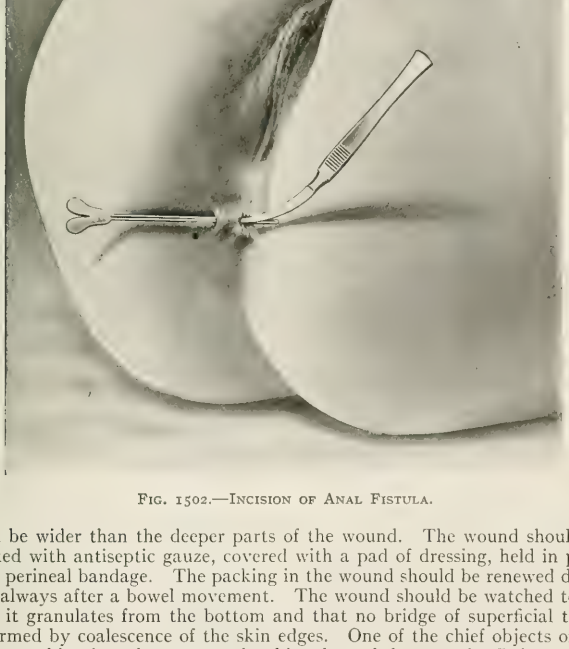


Fig. 1502.—Incision of Anal Fistula.

shall be wider than the deeper parts of the wound. The wound should be packed with antiseptic gauze, covered with a pad of dressing, held in place by a perineal bandage. The packing in the wound should be renewed daily, and always after a bowel movement. The wound should be watched to see that it granulates from the bottom and that no bridge of superficial tissue is formed by coalescence of the skin edges. One of the chief objects of the gauze packing is to keep apart the skin edges of the wound. It is not necessary that the bowel movements be restrained. If the wound becomes soiled with fecal matter it should be irrigated.

It cannot be said that free incision is the only cure for fistula. A fistula without cellulitis may be cured by stretching the sphincter, and then *dissecting out the fistulous tract*. An aseptic operation should be done. The fistula should be cleansed by injecting tincture of iodin. It should be dis-

sected out cleanly without opening it or leaving any of its wall. The resulting wound should be sutured from the bottom with fine chromic catgut, obliterating all spaces, and the skin closed without drainage. I have had much satisfaction in securing primary union in these cases (see Operation for Fistula, Vol. I, page 304).

In some cases it is possible to cure the fistula by *operation without incision.* The sphincter is dilated, the fistula irrigated, and then thoroughly cureted until all vestige of mucous membrane in its lining has been removed. It is again irrigated, and the rectum drained by a rubber tube covered with gauze. This should make a fairly thick plug which keeps the sphincter dilated, compresses the walls of the fistula, and provides for the escape of gas. By having thoroughly emptied the bowel before the operation, and by feeding sparingly with albumin water, whey, broth and grape juice, the bowels may be kept from moving for a week or ten days. During this time the walls of the fistula have coalesced.

In some cases the *elastic ligature* may be used. The cutaneous opening is enlarged by incision toward the anus. The fistula is thoroughly curetted, and an elastic ligature drawn through it and tied with moderate tension. Balsam-of-Peru is injected daily into the fistula. The ligature cuts its way through the tissues, while healing goes on above. A thin bridge of tissue remains, which may be divided under local anesthesia. No discomfort is present after the first few days.

The injection of *bismuth paste* in the treatment of rectal fistula has met with a fair measure of success. If there is an opening into the rectum it should be closed by a finger in the bowel in order to cause the paste to distend all diverticula. (See Bismuth Paste Treatment of Sinuses, Vol. I, page 305.)

Anal Fissure.—The small ulcer or crack in the folds of the anal margin, which does not heal because of constant motion, and which gives rise to a form of peripheral irritation capable of disturbing the whole organism, is easily cured. The simplest treatment consists in dilating thoroughly the sphincter ani. This should be done under general anesthesia. Most cases are cured by this alone.

If general anesthesia cannot be used the disease can be cured by making an incision directly through the base of the fissure well into the sphincter muscle. This incision divides the muscle fibers and places the ulcer at rest; while at the same time local hyperemia is induced. The operation is performed under local anesthesia. By first placing a crystal of cocain on the sore, there is produced sufficient anesthesia to permit an injection of non-toxic anesthetic under the ulcer.

In ulcers and fissures which have existed for some time, sufficient to have developed a deposit of scar tissue, it is best to combine thorough dilatation of the sphincter under general anesthesia with incision of the ulcer and the underlying fibers of the muscle. This is the most satisfactory method in all cases.

Cases in which operation is not to be done may be cured by local anesthesia and the application of the silver nitrate stick to the ulcer. This may be repeated every five days until a cure is secured.

Stricture of the Rectum.—Etiologic factors should be eliminated. Ulcerated areas should be healed. Soft strictures may be dilated with soft rubber rectal bougies (Fig. 1503). These should be well lubricated and passed at intervals varying with the tightness of the stricture. Gradual dilatation is to be preferred. In the case of a rather tight stricture bougies of increasing size may be used every second or third day until adequate dilatation is

secured. No rule can be given. Some cases are made worse by bougies, as they excite inflammation and often bleeding. The intervals must be determined by experiment. Usually after satisfactory dilatation has been secured, the passage of a bougie once a month suffices to maintain it.

In the absence of rectal bougies, dilating instruments such as sounds, uterine dilators, or esophageal bougies may be used. A piece of rubber dam may be inserted in the form of a cone through the stricture and its interior packed with gauze to give dilatation. The ordinary paraffin candle, with its end tapering, may be used in several sizes for dilating low strictures.

Division of the stricture by an incision (internal proctotomy) posteriorly may be practised in dense strictures. Through a speculum the stricture is divided down to normal tissue. The incision may have to go through the sphincter. A dilator should be used afterwards. Dilatation of the sphincter should also be practised at intervals. A posterior incision through both stricture and sphincter may have to be made. In high strictures an anastomosis of the sigmoid may be made with the rectum below the stricture. This may be made at first by means of a button and later enlarged by applying a clamp through the rectum to cut through a spur. Aggravated strictures call for excision of that part of the rectum bearing the disease.

In some cases *external proctotomy* is indicated. The operation is done through the incision used for proctectomy. The stricture is divided posteriorly in the median line external to the mucous membrane.

J. Werner (Surg., Gyn. and Obst., xx, 1915) did an abdominal section, and with the hand in the abdomen pressed the stricture downward over a bougie which was passed from below by an assistant.

Colostomy should always be considered as an accessory step in the treatment of stricture of the rectum.

In *syphilitic stricture*, the constitutional treatment is the main thing. So long as syphilis exists in the patient dilatation or proctotomy tends to aggravate the local disease. The best results will be secured by inguinal colostomy for the formation of an artificial anus, together with local irrigation with cleansing and antiseptic solutions to heal the ulcerative disease which usually is present above the stricture. These measures should be applied while general treatment is going on; and when the constitutional disease has been cured, then dilatation, proctotomy or excision of the stricture may be considered.

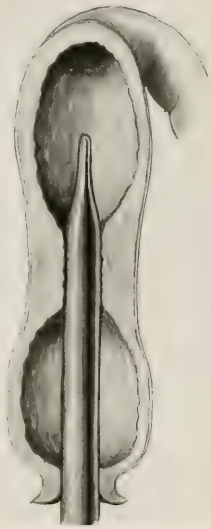


FIG. 1503.—RECTAL BOUGIE.
Showing soft rubber bougie passing through stricture of rectum.

Pruritus Ani.—There are two forms of this disease to be treated. The symptomatic, or false pruritus, requires the elimination of the cause—fistula, ulcer, proctitis, pediculosis, fissure or fungous dermatitis.

True pruritus was discovered by Murray and Meader of Syracuse, N. Y., to be an infection with streptococci, and cured by injections of an autogenous

vaccine made from a culture of the causative organism (Jour. Am. Med. Assoc., Dec. 9, 1911, Vol. lvii). This is perhaps the reason why one of the more effective treatments has been painting the affected area with pure phenol followed with alcohol. Phenol ointment has long been an accepted remedy. Belladonna ointment is at the best but palliative. Injections of alcohol, as for neuralgia, have proved effective.

Operative Treatment.—Ball's operation cuts the skin nerves around the anus. Another operation excises the skin. An incision is carried around the anus just beyond the mucocutaneous junction. An elliptic incision is then made around the disease, the apices of the ellipse being at the median raphe of the perineum and the tip of the coccyx. After excising the intervening skin, the skin outside of the wound is undermined by dissection and sutured across the wound and to the anal skin.

An operation having a similar effect consists in making radiating incisions around the anus. The skin between these incisions is undermined by dissection. Then a snug dressing is applied, or every other one of these loosened flaps may be excised, and then the adjacent flaps sutured together (see *Pruritus*, Vol. I, page 843. Eczema of the anal region is discussed under Eczema, Vol. I, page 832; see also Appendix, Vol. III).

Foreign Bodies in the Rectum.—The removal of foreign bodies from the rectum gives the surgeon an opportunity to apply his ingenuity to the individual case. The shape and size of the object must largely determine the method. Usually with a bivalve speculum the object can be exposed and then grasped with forceps and removed. In some cases it will be advisable to crush or cut in two the foreign body. Round objects may be seized with ring forceps or scooped out with a lithotomy spoon. A wire loop is often of service. An anesthetic should be used if the object is large.

Usually no difficulty is experienced in these operations. If the rectum has been wounded daily irrigation should be practised until the wound is healed. If a considerable laceration exists, the sphincter should be stretched in order to relieve the rectal wall of pressure. It is well worth while taking these precautions to prevent extrarectal infection.

Imperforate Anus and Rectum.—Congenital malformations of the lower end of the bowel present many possibilities of variety, but the most common is that in which the rectum ends in a blind pouch, and the anus is represented by a dimple. The treatment of this condition consists in making an incision at the apparent site of the anus, and by blunt dissection searching for the rectum. By dissecting up in the sacral hollow, the dilated end of the rectum should be found. It should be grasped with forceps, incised and the opening sewed to the skin. Care should be taken not to injure the bladder. If the rectum is not found within 5 cm. (2 inches) of the skin surface, it is advised to discontinue the search. The performance of left inguinal colostomy is recommended in these cases; but it might be possible to continue the dissection from below, open the peritoneum, and bring down rectum, sigmoid, or whatever large gut could be grasped, and suture it to the anal skin.

Cases in which there is a narrowing of the rectum are cured by dilatation. A congenital septum between rectum and anus is easily divided and dilated.

When no sign of anus exists, bulging in the perineum may show the location of the obstructed rectum. When this is present the incision should be made at the tip of the coccyx, and followed closely to the sacral hollow.

Congenital *rectovesical fistula* with imperforate anus should be treated first by the formation of an anal opening. When this has been made, the bladder fistula may be expected to close. If it does not, a permanent tube

should be inserted in the anus to permit the immediate escape of gas and feces so that the rectal wall shall be free from tension. Failure of these measures may be followed by making a temporary left inguinal anus; or the rectovesical opening may be sutured through a suprapubic bladder opening. The best method consists in suturing the openings by operation from below, exposing the bladder by the steps employed for resection of the rectum, separating the bladder from the rectum, and suturing each opening. Following such an operation the bladder and rectum should be treated as described for the treatment of wounds of these viscera.

Congenital *rectovaginal fistula* is remedied by dissecting between the rectum and vagina and separating the two. The vaginal opening is then sutured; and the rectum is brought down and fixed to the skin through an opening made just anterior to the tip of the coccyx.

Prolapse of the Rectum and Anus.—This condition is usually curable without operation. The cause should be discovered, and treatment directed to that. Constipation, diarrhea, defective nourishment, disease of the nervous system, anomalous or acquired weakness of the pelvic floor are some of the things to be looked for and remedied. The next most important thing is to keep the prolapsed part back in place. Remove the causative defect and maintain the bowel in place, and nature will complete the cure by restoring the tone of the muscles which retain it.

A cool enema after each defecation will help restore the tone of the bowel. Electricity to the muscles of the anus is useful.

In children it is important that the protrusion shall be reduced at once after its appearance. The child should be kept healthy and happy. Its crying should be reduced to a minimum. When the bowel comes down, the mother should lay the child on her lap on its abdomen, and with some sweet oil on her fingers gently press back the protrusion. When this fails reduction may be accomplished by suspending the child by its ankles.

Still better than reducing the prolapsus is the prevention of its occurrence. By placing two narrow adhesive straps across the buttocks, strapping them together across the anus, the latter is supported, and prolapse is not apt to occur. Defecation, if soft, takes place without difficulty, after which the straps should be removed, the parts cleansed and dried, and the straps replaced. Or the straps may be removed once daily for defecation.

In adults retention of the bowel is the important remedial measure after correction of the cause. A firm pad or a rubber ball held against the anus by adhesive strips is of service in keeping back the bowel and allowing the stretched parts to contract and regain their tone. Astringent enemata also are useful.

When these measures, after a fair trial, fail, then *operative treatment* is called for. In prolapse of the anus and in a minor degree of the rectum, *treatment with the cautery* is useful. The bowels are well emptied by two days of laxatives and fluid diet. A final enema is given, an hour before operation. General anesthesia is used. With the bowel in a state of prolapse, a cautery, heated to a cherry red, is drawn slowly along the mucous membrane in the long axis of the bowel. About six of these lines are burned. The heat should scar the mucous membrane, and cause inflammatory reaction of the submucous layer, but should not burn through to the muscularis. The prolapse is then reduced and an opium suppository inserted. The operation should be done only in reducible cases. It may be performed through a speculum with the bowel reduced. Bowel movements should be restrained for five or seven days; and the patient should be kept recumbent and defecate only in the recumbent position for two weeks.

The method advocated by Sick consists in *tamponing around the rectum.* An incision, 2 cm. ($\frac{3}{4}$ inch) long, is made in the median line between the tip of the coccyx and the sphincter into the loose tissue behind the rectum. The connective tissue is then separated by a blunt instrument up to the promontory of the sacrum. A passage is made also around the lower part of the rectum. A strip of gauze folded 4 or 6 times is then passed up behind the rectum to the promontory. Strips of gauze are also passed about on either side of the rectum. The ends of the gauze are left in the wound, and the wound is sealed with collodion. The child is kept in bed and defecates only in the recumbent position. The gauze is removed at the end of five days, but the patient should be kept recumbent for two or three weeks, in order that firm adhesions may fix the rectum to the pelvis. The method is especially applicable to children.

The *perirectal injection of alcohol* is useful in some cases. Under general anesthesia the prolapse is reduced and 3 to 10 c.c. (45 to 150 minims) of alcohol injected, in the connective tissue above the sphincter around the rectum. The injections are best made by three punctures—behind and at the sides of the rectum. The patient should be kept constipated for three or four days, and then permitted a soft defecation. A firm pad should be worn for two weeks.

The *injection of paraffin* on either side of the rectum has found favor in some hands.

An *operation for narrowing the caliber of the rectum* may be done as follows: An incision is made from the tip of the coccyx nearly to the anal margin in the middle line. Through this the rectum is dissected free by a blunt instrument. It is then caused to prolapse if not already in that condition. A longitudinal fold is sewed into the posterior wall of the rectum by catching the rectal wall first on one side and then on the other with a curved needle carrying chromicized catgut. As each suture is tied the rectum is pushed up a little. When the lowermost suture has been put in, the caliber has been narrowed, the prolapse reduced, and conditions for the production of adhesions created. This operation is applicable to adults.

The *amputation of the prolapsed rectum* is indicated in intractable cases, especially of the irreducible variety. The prolapsed bowel is held with a cloth and an incision is made across the front of the mass about a finger's breadth below the anus. If the peritoneal pouch is below this incision it is carefully opened, and any bowel or omentum which it contains is pressed back with a gauze sponge, and the anterior edge of peritoneum sewed to the peritoneum of the posterior wall of the pouch. The peritoneal cavity is thus closed. The amputation of the prolapsed rectum is completed by carrying the incision around the bowel. The outer tube is cut through, and the free end allowed to drop. Before cutting through the inner tube, it should be caught with forceps to prevent its retraction out of reach. The cut edges of the two tubes are sewed together, and the place of union pressed up within the sphincter, an opium suppository should be introduced. The bowels should not move for five days or a week.

The operation of *proctopexy* for holding up the prolapsed rectum is to be preferred in intractable cases in adults in which there are no adhesions or ulceration, and in which reduction is not difficult. A suprapubic abdominal section is done to the left of the median line, and the patient placed in the elevated pelvis position (Trendelenburg). The prolapsed bowel is drawn up by traction on the sigmoid. The mesentery of the lower sigmoid is then sewed to the parietal peritoneum at the brim of the pelvis or higher in front of the psoas iliacus. By sewing the peritoneum in several places and rubbing

the surfaces with a knife blade adhesions will help to give a permanent support.

Many forms of *intestinal anastomosis for rectal prolapse* have been done. In rare cases some such operation may be found to be indicated. The best of these intestinal operations consists in pulling up the prolapsed rectum from the pelvis and making a lateral anastomosis between the rectum and the beginning of the sigmoid or end of the descending colon. This anastomosis should be broad, and made with three rows of sutures. McArthur and Andrews (Jour. Am. Med. Assoc., July 28, 1911) who recommend this operation have found that it suffices without operation on the perineum. There are most probably cases with relaxation of the perineal floor which will require in addition plication of the lower end of the rectum.

Hemorrhoids.—*Internal hemorrhoids* should first have applied for their relief measures to correct or remove any remediable causative influence. Diseases of the heart and circulation, constipation, straining at stool, sedentary habits which produce venous stasis, overeating, excessive use of tobacco, diarrhea, overwork and physical straining, cirrhosis of the liver, repeated fatigue in the standing position, and intra-abdominal tumors are some of the conditions commonly requiring attention. Improvement of the general health of the patient is always of help.

Moderate-sized, recent hemorrhoids may be cured by general hygiene and elimination of the cause. Regulation of the bowels is most important. Laxative medicines should be used, at the most, only temporarily. A daily cleansing enema and hygienic living will often result in a cure of the disease. The old-fashioned compound licorice powder, sulphur and cream of tartar, or confection of sulphur is most useful when a medicinal laxative is needed. For giving tone to the circulatory system there is value in a pill of ergotin, 0.2 to 0.6 Gm. (3 to 10 grains); strophanthin, 0.00025 to 0.001 Gm. ($\frac{1}{240}$ to $\frac{1}{60}$ grain); and hydrastin hydrochlorate, 0.03 to 0.06 Gm. ($\frac{1}{2}$ to 1 grain).

A flabby and relaxed state of the mucous membrane may be remedied by the use of mild astringent applications. A suppository composed of 0.2 to 0.3 Gm. (3 to 5 grains) of ichthyol in cocoa butter is effective. Tannic acid, 0.3 Gm. (5 grains), in a suppository may be used; or a cleansing enema, followed by the injection of 15 c.c. ($\frac{1}{2}$ ounce) of fluid extract of witch hazel. If there is some irritation the astringent treatment may be preceded by placing 0.03 to 0.06 Gm. ($\frac{1}{2}$ to 1 grain) of cocain in the rectum, and adding 0.06 Gm. (1 grain) of extract of hyoscyamus to the astringent suppository.

Other drugs which may be made into suppositories and which possess soothing properties are iodoform, 0.06 to 0.3 Gm. (1 to 5 grains); phenol, 0.06 to 0.18 Gm. (1 to 3 grains); powdered opium, 0.06 to 0.12 Gm. (1 to 2 grains); hydrastin 0.015 to 0.06 Gm. ($\frac{1}{4}$ to 1 grain); creosote, 0.06 to 0.18 c.c. (1 to 3 minims); and the local anesthetics. Other astringent drugs which may be used in suppositories are adrenalin; acetate of lead, 0.03 to 0.12 Gm. ($\frac{1}{2}$ to 2 grains); sulphate of zinc, 0.03 to 0.12 Gm.; or sulphate of copper, 0.03 to 0.12 Gm. A suppository may be made with 1 to 2 Gm. (15 to 30 grains) of cocoa butter.

Simple stretching of the sphincter helps in the cure of moderate hemorrhoids when there is undue tonicity of that muscle. A fissure or ulcer may be found to be responsible for this. Gentle and constant pressure was recommended by Toth. This may be made by means of a pledget of absorbent cotton, the size of a large pea, placed between the lower and upper sphincter. Such a pledget is kept constantly in place and is renewed after each defecation.

Treatment by the *injection of phenol* is dangerous because a slough may

form and become infected. Pyemia and hepatic abscess have followed this treatment. It is justified only when the patient understands the risk, when an anesthetic cannot be administered, and when a surgeon capable of performing a safer operation cannot be had. The technic consists in cleansing the rectum and anus, extruding the pile, supporting it by a finger in the rectum, and the injection made. A 10 per cent. solution of phenol in equal parts of water and glycerin is used in a hypodermic needle. Five or six drops (0.3 c.c.) are injected into the middle of the pile. The pile is then smeared with vaselin and returned to the rectum. Phlebitis is thus excited and a clot formed which ultimately cures the hemorrhoid. The operation is repeated at intervals for each pile mass.

The *injection of quinin* and *urea chlorid* into the pile mass, in amounts not exceeding 0.12 to 0.5 Gm. (2 to 8 grains) of the drug, causes atrophy and

FIG. 1504.—OPERATION FOR HEMORRHOIDS.
The pile is grasped by ring forceps, the mucous membrane about its base is divided, and a threaded needle is passed eye-first through its base.

disappearance of the pile. The method is safer than the injection of phenol. The strength of the solution need not be more than 5 or 10 per cent. to be effective. A small conical fenestrated speculum is introduced and the injection made. The average case is cured in about six weeks. Symptoms in most cases are relieved in a week or ten days. The treatment is painless. The patient is not detained from business.

Hemorrhoids not yielding to the above measures should be cured by operation. Aggravated hemorrhoids should not be temporized with but should be operated upon at once.

Of the *operations for hemorrhoids*, there is a large number. The important features are that the operation should (1) cure the disease, (2) be capable of expeditious execution, (3) sacrifice a minimum of blood, (4) be free from danger of postoperative hemorrhage, (5) leave no stenosing scar, (6) invite the least infection, (7) be capable of performance under local anesthesia and (8) cause the minimum amount of pain.

The following operation by the *ligature* and *suture method* comes near to these requirements: The bowels are well cleared out by two days of intestinal irrigation and fluid diet. If hairy, the anal region should be shaved. A small enema is given two hours before operation. A general anesthetic (ether) is to be preferred if there are no contraindications. The operation may be done with local anesthesia. The patient is placed in the position for anal operations. The anus and buttocks should be well cleansed, and the sphincter stretched until it is thoroughly relaxed.

The largest posterior pile mass is grasped by ring forceps, lifted up and an incision made with scissors or knife about the lower part of its base at the mucocutaneous border. This should be a U-shaped incision. It is deepened

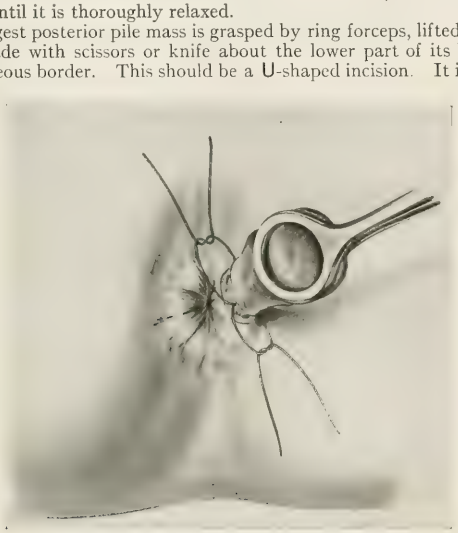


FIG. 1505.—OPERATION FOR HEMORRHOIDS.
Pedicle of pile has been transfixed with double ligature, and ligatures about to be tied on either side.

with scissors and by blunt dissection, separating the pile from the sphincter, until the blood-vessels of the pile are approached (Fig. 1504). There is practically no bleeding. Lastly the circumcision of the pile may be completed by continuing the incision through the mucous membrane, converting the U into an O. The disadvantage of completing the incision is that vessels may be cut, as the veins lie close to the surface here.

A ligature of chromic catgut is then tied around the pedicle which consists of connective tissue and the blood-vessels. If the pedicle is large a curved needle should be used to transfix the pedicle. It should carry catgut enough for two ligatures, and should be passed eye-end first in order to injure the blood-vessels as little as possible (Fig. 1505). The pedicle is then ligated in two sections, and the top of the pile cut away. Enough stump should be left to prevent slipping of the ligatures.

The time of the operation may be shortened by omitting the complete circumcision of the pile and leaving the incision in the shape of a U. The only objection to this is that the ligature is then tied down upon the mucous membrane which later gives some aching pain.

The wound external to the ligature may be closed by a few sutures if large enough to require closure (Fig. 1506). It is not wise to suture the mucous membrane over the stump if the stump contains some mucous membrane; but this may be done if the stump has been denuded of mucous membrane.

The closer together the two arms of the U-incision are made, by encroaching upon the mucous membrane of the pile, the more easily is the wound closed by sutures. A strip of unharmed mucous membrane should be left between each pile mass operated upon. The important step is the ligature about the upper half of the pile. This controls the vessels from which hemorrhage is most apt to occur. It is for this reason that if complete circumcision of the pile is done it must be done carefully. Usually it is best omitted.

The same operation is repeated with each major pile mass—usually three, to five. At the close of the operation there should be no bloody oozing. An opium suppository is introduced in the rectum. A wick drain is passed through the anal orifice, as a signal in case of hemorrhage, and over all a mass of gauze held in place by a perineal bandage. It there is any bleeding its source should be discovered and it should be checked before sending the patient to bed.

The bowels should be kept from moving for two or four days, at the end of which time a dose of castor-oil should be given, followed in four or five hours by an enema of olive oil. The patient should be kept in bed ten days.

The *simple ligature method* may be used instead of the above operation in cases in which greater haste is required or in which the lower vessels are very large. The clamp is applied to the pile. The needle, carrying thread enough for two ligatures, transfixes the pile in its middle. One ligature is tied above and the other below, each embracing half of the pile. The pile is then cut off beyond the ligature. For this operation a large ring clamp or a T-clamp is to be used. Enough of the pile mass should be left to prevent the ligature from slipping off.

In performing the ligature operation, before introducing the ligature, the mucous membrane or skin around the lower border of the pile should be cut through with knife or scissors. This provides a groove into which the ligature may sink, prevents pressure upon the sensitive nerve ends at the mucocutaneous border, and obviates ligating a mass of tissue which is free from large vessels. If the mucous membrane about the upper half of the pile is divided, there is danger of bleeding.

Each pile mass is ligated in this manner. From one to four or five masses may quickly be disposed of. The after-treatment is the same as described above. This is the most simple, the easiest, and the most quickly applied operation for hemorrhoids. It is highly satisfactory. Chromicized catgut is used for ligatures.

Operation by the *clamp* and *cautery method* is preferred by some surgeons. Each pile mass is seized by an especially constructed clamp, having a narrow bite and great crushing power. It acts as an angiotribe, but to make the operation sure and cover the stump with an aseptic cap, the pile beyond the clamp is burned off with the cautery. The skin should not be burned. There is some danger of hemorrhage following this operation. The results are usually good, and no blood is lost.

The operation of *circular excision of the pile mass* (Whitehead) is applicable to large, succulent piles which encircle the rectum and tend to prolapse. In such cases individual piles could with difficulty be singled out for attack. The preliminary preparation is the same as for other operations.

The sphincter is stretched. Four ring clamps are placed on the mass at equal distances apart. An incision is made with a knife at the mucocutaneous border around the anus. Another set of clamps is applied to the cut edge, and the mucous membrane bearing the hemorrhoids is dissected free from the sphincter muscle. This dissection is best made with blunt-ended scissors, and is largely a blunt dissection. There should be but little bleeding. The clamps on the edge are used as tractors to draw down the tube of mucous membrane representing the lining of the anus and lower rectum.

When the dissection has reached the upper limit of the piles the mucous membrane is sutured to the skin edge as the lower end of the rectal mucosa is cut away. It is possible to apply the suture completely around the opening before the pile mass is amputated. This prevents bleeding. Most surgeons prefer to make a short transverse cut through the mucous membrane, and then suture that segment. The cut is then made 1.3 cm. (½ inch),

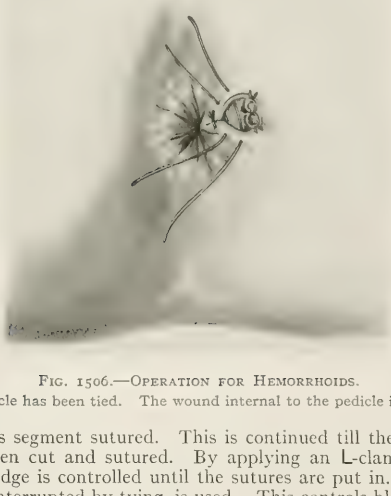


FIG. 1506.—OPERATION FOR HEMORRHOIDS.
The pedicle has been tied. The wound internal to the pedicle is sutured.

longer and this segment sutured. This is continued till the whole circumference has been cut and sutured. By applying an L-clamp, hemorrhage from the cut edge is controlled until the sutures are put in. A continuous suture, often interrupted by tying, is used. This controls bleeding from the edge of the mucous membrane.

Too much tension on the wound means separation and an annular cicatrix. A rubber tube covered with gauze should be placed in the rectum through the sphincter. This carries off gas and makes gentle pressure. The bowels should not move before the fifth or seventh day. A small amount of opium daily insures constipation. This operation in skilled hands gives good results; in the hands of the inexperienced it is dangerous.

External hemorrhoids require no treatment unless they cause symptoms from which the patient desires to be relieved. Thrombosis often occurs and effects a spontaneous cure. Tabs of skin hanging about the anus are not hemorrhoids, but may be removed for the sake of cleanliness and esthetics.

The operation for external hemorrhoids consists in making an elliptic incision, radiating from the anus, and deepening it sufficiently to permit the application of a ligature into the sulcus thus formed. The incision should be carried down to the vessels. If the pedicle is broad, it should be transfixed and ligated in two sections. The tumor is cut away leaving enough stump to hold the ligature. If no skin is left on the stump, the wound should be closed by sutures.

Strangulated hemorrhoids, extruded piles prevented from returning by contracture of the sphincter, should receive prompt attention because of the pain the patient suffers and the danger of gangrene. The surgeon should make an attempt by gentle pressure with the palms of the fingers to effect reduction. Anointing the parts with vaselin helps. Commonly the edema will prevent reduction. The pain should be allayed by a suppository of opium and hyoscyamus and the patient placed on a bed which does not permit downward sagging of the pelvis. The elevated pelvic position is desirable if the patient will tolerate it. A cooling solution should be applied on gauze covering the piles. Acetate of aluminum solution or fluid extract of witch hazel or alcohol and water are useful. After a few hours the pain subsides, but the strangulation persists. By keeping the pelvis elevated, applying evaporating lotions, and moving the bowels by means of enemata, the swelling subsides and reduction becomes possible. From two to fourteen days may be required.

Operation for the radical cure of strangulated piles at an early stage is not to be recommended. The tissues are infiltrated, the patient's nervous system is disturbed, retention of urine may be present, and it is possible to allay the pain and secure better general and local conditions before operating.

In many cases, by leaving the piles extruded a thrombophlebitis develops and effects a spontaneous cure. In fact I. Boas (Archiv für Verdauungs-Krankheiten, April, 1909) adopted this *extra-anal method of treating hemorrhoids*. He caused extrusion of the piles by the patient's straining, supplemented, if necessary, by suction apparatus. The patient is kept quiet for a few days, and is then allowed to walk about. This constitutes the treatment. One or two weeks suffice to see the piles become thrombotic, shrink, and disappear. The pain during the first two or three days, if severe, is controlled by suppositories of morphin or codein. Usually nothing more than a dressing of acetate of aluminum is necessary.

Ulcerated hemorrhoids should be treated by regulating the bowels, rectal irrigation, and touching the ulcerated surfaces with 2 per cent. silver nitrate solution. If the ulcerated surface is on a strangulated pile, calomel or some other dusting powder should be applied.

Inflamed hemorrhoids should be treated by emptying the bowel, by rectal irrigation, fluid diet, and the recumbent position. A suppository containing 0.3 Gm. (5 grains) of ichthyol may be used once daily. Hemorrhoids subject to ulceration and inflammation should be gotten into a healthy condition and operated upon.

TUMORS OF THE RECTUM

Benign tumors which are sessile and not large enough to cause symptoms require no operation. *Fibroma, lipoma* and *myoma*, when small, do not need operation. All benign tumors are prone to develop into polypi or to cause prolapse, and when these conditions appear the tumor should be removed. *Condyloma* and *papilloma* of syphilitic and gonorrheal origin should receive the treatment which these specific diseases require. *Adenoma* of the rectum should be removed by excision when it shows signs of becoming pedunculated;

and in persons over twenty-five years of age the disease should receive the same treatment as carcinoma (at least until skill in differential diagnosis of these two conditions has reached a higher degree of perfection than it has yet attained). *Angioma*, when small, requires no treatment; when hemorrhoidal in character or large enough to cause symptoms, it should be treated by the methods already described.

Sessile tumors may be removed by an elliptic incision, and the wound closed. Such operations may be carried out through the rectal speculum. *Rectal polyps* are best removed by a wire snare operated through the speculum. When the pedicle is large or vascular a ligature should be tied about it, and the pedicle cut well beyond the ligature. Adenomatous polypi in adults should be treated not by amputating the base but by excising by an elliptic incision that part of the rectal wall from which the polyp springs, and suturing the wound. This is done because of the proneness of malignant degeneration in these tumors. By using adrenalin to prevent bleeding the operation need not be difficult.

Benign tumors or small malignant tumors, which cannot be operated upon through a speculum, may be attacked by external proctotomy. Malignant tumors of the rectum require wide excision of that part of the rectum bearing the tumor.

Malignant tumors of the rectum are at first local and curable. Ultimately the disease extends and becomes disseminated, general, and incurable. Operation in the early stage is imperative. If the local disease is removed, the patient is cured.

Cancer of the rectum is irritated, and ulceration is provoked by the presence in the rectum of innumerable bacteria and fecal matter. A favorable influence in retarding the progress of the growth and its breaking down is exercised by diverting the fecal current by means of a left inguinal artificial anus when immediate extirpation of the disease cannot be practised. This should be done in inoperable cases; and a surprising degree of comfort may thus be secured for the patient, and considerable prolongation of life.

Operative treatment of cancer of the rectum should be governed by the size and location of the growth. A small tumor, sessile or pedunculated, may be removed by wide excision of the rectal wall, bearing the growth, and suture of the wound. An elliptic mass is best removed, embracing 1 to 1.3 cm. (⅓ to ½ inch) of sound tissue on either side of the disease. This can be done through the dilated sphincter or by *external proctotomy*. In annular carcinoma a segment of the rectal wall must be resected, lymphatics removed, and the sound bowel above brought down across the gap to be united with the skin or anal orifice below, or abdominal colostomy done.

The operation of *external proctotomy* is performed for exposure of the interior of the rectum. An incision is made from the tip of the coccyx to the anus in the middle line. Bleeding is controlled as the operation proceeds. The sphincter is divided, the rectum laid open, and the object of the operation attained. The wound is closed by layer sutures.

In growths of the posterior wall of the rectum the rectal wall is not split, but the dissection is carried as far as the growth and then an elliptic resection made.

Instead of the posterior operation, *vaginal proctotomy* may be done in the female. The resulting wound is closed as a complete rupture of the perineum, if the sphincter is divided, and as a rectovaginal fistula, if the sphincter is not divided.

Proctectomy is done through the perineum, through the abdomen above the pubes, through an opening made by resection of the coccyx and sacrum,

through the vagina, or by combining two or more of these routes. Proctectomy may be complete (involving the whole rectum and anus) or incomplete.

When resection or amputation of the rectum is to be done, making a preliminary inguinal anus is often desirable. This has two great advantages: it improves the patient's general condition and enables him to tolerate better, in the course of from one to four weeks, the radical operation; and it insures the success of the operation by diverting the fecal current from the field. After the rectal wounds have healed the artificial anus may be closed. Notwithstanding these advantages, most surgeons who are doing amputation of the rectum are not performing this preliminary operation. It offers a decided disadvantage if abdominal section is to be a part of the operation for radical cure; and the surgeon cannot always be sure that he shall not need to open the abdomen above the pubes. Sigmoid colostomy is also a hindrance if pulling down the sigmoid becomes necessary, as it may. When it is fairly clear that the operation can be done wholly below the pubes, preliminary colostomy is highly desirable. Some surgeons have done colostomy at the same sitting with the radical operation, in order to divert the fecal current from the operative wound.

There are a number of acceptable procedures for the removal of a segment or all of the rectum. The surgeon should employ the one which is most applicable to the specific case, or the operation to which his hands are most accustomed.

Twisting the lower end of the bowel before suturing it to the skin greatly increases the danger of gangrene.

In cases of low carcinoma in which the sphincter must be sacrificed, it is a good plan to close the anal orifice by suture as soon as the incision about it has been made.

The immediate mortality following extra-abdominal resection and amputation for cancer of the rectum has been between 7 and 15 per cent. Operations performed from below show lower mortality and higher proportion of recurrences. Suprapubic operations, combined with the low operation show higher operative mortality (10 to 20 per cent.) and lower proportion of recurrences.

The *preliminary preparation* should consist in thorough evacuation of the bowel by irrigation for several days before operation. At the time of operation the sphincter should be stretched if it is to be preserved; and the rectum tamponed with gauze if the low operation is to be done.

Excision of the rectum through the anus may be done for low-lying early carcinoma. The sphincter is dilated widely. If necessary an incision may be made back to the coccyx. The segment bearing the tumor is caused to prolapse, and the operation proceeded with as for circular excision of hemorrhoids (Whitehead). The operation differs from that for piles in that the whole thickness of the rectal wall is removed. After excision of the diseased segment the upper end is united to the remaining bowel at the anus and the wound closed. The surgeon rarely sees a case of carcinoma early enough for this operation.

Excision of the rectum by the postrectal route is done for low-lying disease the upper limit of which is not more than 10 cm. (4 inches) above the anus, and which is believed not to have upward metastases. If the sphincter is not involved it should be preserved, provided the nerve supply, which reaches it from the sides, is not destroyed. The patient is placed in the elevated-pelvis position with the hips and knees flexed. Some prefer the lateral pelvic position (Sims), or the prone flexed-thigh position (Fig. 1507). A U-

shaped incision is made, beginning 2 cm. (¾ inch) in front of the anus and each arm about 7 mm. (¼ inch) from the middle line. This incision is

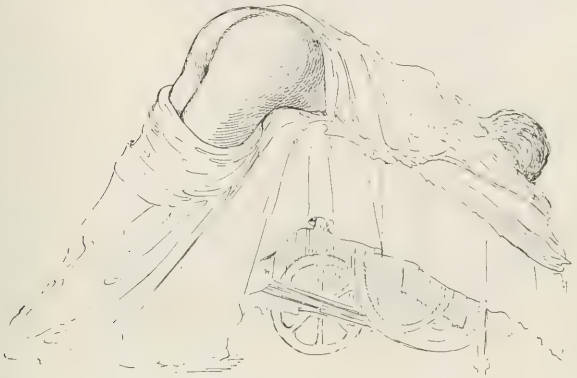


Fig. 1507.—Position for Proctectomy and Other Major Rectal Operations.

carried about the anus and joined in the middle line by an incision which passes to the middle of the coccyx (Fig. 1508).

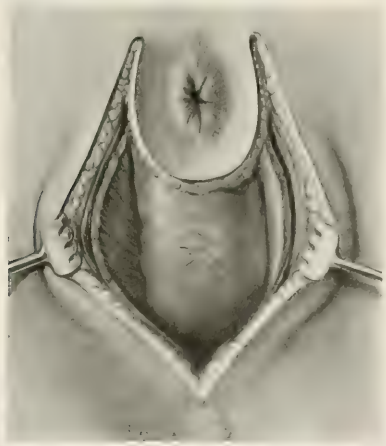


Fig. 1508.—Incision for Proctectomy.
Patient in dorsal position.

The incisions enter the ischiorectal fossa, and the dissection is carried up to the levatores ani muscles. The rectum is carefully separated in the

male from the prostate, bladder and urethra. To prevent wounding these organs a sound should be held in the bladder. The index-finger of the left hand in the rectum aids in the dissection. The index-finger in the vagina helps identify this organ. The levatores ani muscles are divided. The peritoneum should not be opened unless necessary. Vessels are clamped and tied as the operation proceeds. Blunt dissection and an occasional cut with the scissors free the rectum. The bowel, having been freed, is clamped and cut across about 2.5 cm. (1 inch) above and below the growth in case of cancer.

If the growth is within 2.5 cm. (1 inch) of the sphincter, the latter must be sacrificed.

An opening in the peritoneum should be packed with gauze as soon as made, and sutured after resection of the rectum. When the sphincter is saved the upper segment of bowel is brought down and sewed to the short lower end by one of the methods of end-to-end entero-anastomosis already described. If the sphincter has been removed the levatores ani should be sutured about the rectum. The anal outlet may be tightened by rotating the bowel from 180 to 360 degrees and suturing it to the skin in the back part of the wound. The rest of the wound should be closed. Comparatively few cases of carcinoma are seen by the surgeon early enough for this operation.

Excision of the rectum through the perineal route can be done in early cases by way of a long transverse incision midway between the rectum and the posterior border of the vulvar orifice. Through this incision the recto-vaginal space is opened, the rectum isolated, and excised. It is applicable to exceptional early cases.

Excision of the rectum by the sacral route involves resection of the coccyx together with a part of the sacrum lying below the third sacral foramina. The patient is placed in the extreme elevated pelvic position, with hips and knees flexed. Some surgeons prefer the right lateral prone position with thighs flexed. Others operate with the patient in the knee-chest position, supported under the pelvis and with the chest resting on a cushion; or the prone flexed-thigh position may be used.

An incision is made in the middle line from the second spine of the sacrum to the posterior margin of the anus. This is carried down to the bone. The soft parts are loosened and retracted to the left to expose the left side of the sacrum and coccyx, and to the right to expose the right side of the coccyx. The soft structures connected with the coccyx are divided, and the coccyx removed. This may prove to give sufficient room without resection of the sacrum. If more room is required a periosteal elevator is passed around the side and in front of the sacrum to separate the venous plexus and sacra media vessels, and part of the left side of the sacrum is removed. This may be done with the wire saw (Gigli), chisel, or bone forceps. The soft parts are retracted, and the sacrum divided from a point just below the left third posterior sacral foramen, downward and inward and then through the right fourth posterior sacral foramen to the right edge of the sacrococcygeal joint. If still more room seems to be needed the sacrum may be divided transversely just below the third sacral foramina.

The soft tissues which have been separated from the bones are the attachments of the gluteus maximus muscle, sacrosciatic ligaments, coccygei, part of left pyriformis, and levator ani muscles. Vessels are caught and ligated. Vessels in the bone are controlled by pressure. The levatores ani and other soft tissues in the middle line are incised and pressed apart and the rectum exposed. If the disease is not nearer than 2.5 cm. (1 inch)

to the anus, the sphincter is left. The rectum is dissected free from its connective-tissue bed, and drawn down as the dissection proceeds. It should be divided across at least 2.5 cm. (1 inch) below the disease, being clamped or ligated before it is cut (Fig. 1509).

The dissection now proceeds upward, the rectum being drawn down, while a sound in the bladder in the male identifies that viscus and the urethra, and a finger in the vagina saves that organ from injury in the female. The reflection of peritoneum on the anterior surface of the rectum should be pressed upward out of the way, but if the disease approaches it within 2.5 cm. (1 inch) it should be opened and protected by a peritoneal pad. In the male the peritoneum descends on the rectum to about 7.5 cm. (3

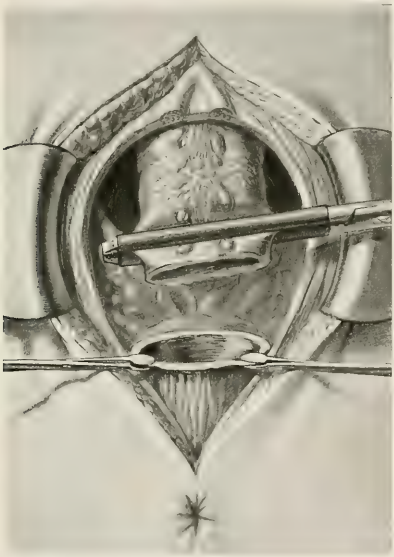


FIG. 1509.—EXPOSURE OF RECTUM BY THE SACRAL ROUTE.
Patient in ventral position. The bowel has been clamped and divided below the disease.

inches) above the anus. At the level of the third sacral foramen the peritoneum nearly surrounds the rectum and forms a mesorectum.

The rectum should be freed for 5 cm. (2 inches) above the tumor, clamped and cut across at least 2.5 cm. (1 inch) above the disease. The resected segment is removed. Bleeding is controlled, and the peritoneum closed.

In separating the rectum it should be remembered that the rectal branches of the inferior mesenteric artery run in the mesorectum close to the bowel, therefore the dissection should keep near to the sacrum. By dividing the tissues close to the sacrum the rectum may be freed for some distance above the point of division and greater mobility of the stump secured.

If the sphincter and the anus have not been removed, the upper segment

should be sutured to the lower by the method already described for end-to-end intestinal suturing. If the sphincter and anus have been removed, the terminus of the bowel is sutured in the posterior angle of the wound. Witzel made an opening above the lower border of the gluteus maximus, drew the bowel through the muscle, and sutured it to the skin. Gersuny twisted the bowel upon its long axis, in order to narrow the new anal orifice, and sewed it to the skin. Keen did a preliminary inguinal colostomy to make a permanent artificial anus, and closed the lower segment of the bowel.

Excision of the rectum by the vaginal route is begun by a median incision through the posterior vaginal wall. If necessary the incision is carried around the anus. If the disease does not require removal of the anus, the rectum is isolated by dissecting around it. As the dissection is carried upward, the peritoneal reflection covering the upper posterior fifth of the vagina is opened and the peritoneal cavity packed off with pads. The rectum is then freed as high as necessary, cut across, and the stump brought down and sutured at the anus. The divided muscles are sutured, and the vaginal wall closed separately.

Excision of the rectum by the abdominal route, or combined method, is the one-stage operation of choice. It is not done in cases of early low-lying disease.

The abdomen is opened in the middle, with the patient in the lowered head position (Trendelenburg). The sigmoid is picked up at a place where the mesocolon is long enough to permit the bowel at that point to be carried to the anus. This is well above the rectum and at a place where free anastomosis between the branches of the inferior mesenteric artery exists. Two heavy silk ligatures about 2.5 cm. (1 inch) apart are thrown about the bowel, and the bowel ligated in two places. It is then divided by means of the thermocautery between the two ligatures, and the mucous membrane of the stumps is sterilized. An aseptic division and closure of the bowel has now been accomplished. The upper end is covered with gauze.

The peritoneum is then divided on either side of the rectum, in lines parallel with the bowel, from the mesenteric wound downward. This division is carried as far as the cul-de-sac, and thence across in front of the rectum through the bottom of the cul-de-sac. The incision should be about 2.5 cm. (1 inch) away from the bowel to preserve the arched branches of the mesenteric artery. The distal part of the sigmoid and the rectum are dissected free from their bed. The dissection is carried downward as far as possible toward the anus. The extent of this dissection will vary with the anatomic conditions and the facility of the operation. But with the pelvis well elevated, and empty of all intestines except the segment to be removed, the dissection may be carried well down about the rectum nearly to the anus.

The sphincter having been dilated, a long clamp is passed into the rectum and caused to grasp the inverted end of the lower bowel segment or a ligature. This is drawn out through the anus, the rectum turning inside out as it descends. The lower end of the remaining bowel, the upper segment, is then observed with reference to the possibility of suturing it at the anus. If it is long enough it is left *in situ* and the long ends of its ligating suture are poked down inside of the inverted lower segment. The peritoneum reflected from the bowel to the pelvic brim is then sutured around the proximal segment and the abdominal wound closed.

The patient is then placed on the side or back with hips and knees flexed and the operation completed from below. Some surgeons prefer to place the patient in the prone position with the thighs flexed on an angular table. The inverted rectum is amputated above the sphincter. The mucosa is

removed as far as the skin. The stump of the sigmoid is brought down and sutured to the skin at the anal orifice. If thought necessary an opening may be sutured to the skin at the anal orifice. This is done with an interrupted suture of silk. If thought necessary an opening may be made at the tip of the coccyx and a drain introduced into the perirectal space.

Comments on the Abdominal Operation.—This operation is less apt to be followed by recurrence than is the low operation, and possesses the great advantage that the surgeon is not required to save as much of the bowel, close to the disease, as possible.

If upon exposing the sigmoid at the beginning of this operation it is found to have too short a mesocolon to permit its attachment at the anus, as above described, three alternatives remain: (1) An inguinal anus may be made with the upper end instead of carrying it to the natural anus; (2) the inferior mesenteric artery may be tied just below the left colic branch and the division of the mesentery continued up far enough to immobilize sigmoid to reach to the anus; or (3) the operation may be done higher up, even at the transverse colon, where mesentery of sufficient length is found. In the latter event it is not necessary to resect all of the bowel between the place selected for the colo-anal anastomosis. The bowel may be divided about the proctosigmoid juncture or well above the disease and the two ends closed, catgut being used for the upper segment. The extirpation of the rectum is then proceeded with as above. Instead of bringing down the stump of sigmoid, a loop of colon higher up is brought down and anastomosed with the anus.

Of these expedients, elongation of the sigmoid is best.

The removal of lymph-nodes can be accomplished by the abdominal route as by no other method; and as metastases tend to develop upward, this being the general direction of the lymph current, the abdominal operation must be looked to as of the greatest usefulness in advanced cases of cancer of the rectum.

This dissection of the lymphatics should follow division of the mesentery. The ureter and iliac vessels should be identified, and then the dissection should remove all lymphatics and connective tissue lying under the peritoneum above and about the rectum.

If the tumor mass is so great as to prevent inversion of the rectum, a clamp is applied above the anus and well below the tumor, and the rectum cut across below the clamp and removed.

If it becomes advisable on account of the condition of the patient, the operation may be terminated at almost any stage by bringing the lower end of the upper segment into an inguinal opening, and completing the extirpation of the rectum from below at a subsequent operation.

Excision of the rectum by the two-stage abdominosacral operation is the most thorough and hopeful of all operations. It has been worked out especially by W. J. Mayo (Annals of Surg., vol. 56, 1912), Dahlgren (Zentralb. f. Chir., March 29, 1913), R. S. Coffey (Annals of Surg., April, 1915), and D. F. Jones (Jour. Am. Med. Assoc., August 28, 1915).

The abdomen is opened in the median line. The mesentery of the sigmoid flexure and descending colon is exposed and the inferior mesenteric artery is tied just below the place where the left colic branch goes off from it. The artery is tied in two places and cut between. The points at which amputation is to be done is then determined. An incision is carried through the peritoneum of the mesentery of the sigmoid on either side, 2.5 cm. (1 inch) away from the bowel and parallel with it, sparing the vascular arch. The peritoneum is dissected free, and the mesenteric and subperitoneal connective

tissue and lymphatics dissected out and removed from the point of ligation of the inferior mesenteric down into the pelvis as far as the levator ani muscle. At the rectovesical fold the incision of the peritoneum is continued around the bowel, and the bowel separated from the bladder. The excavation around the rectum is then lined with a sheet of rubber protective, and gauze packing is placed between the rectum and the protective. The two leaves of peritoneum are then sutured over the ureter, iliac vessels and around the rectum (Fig. 1510). This step isolates the sigmoid, leaves it without mesenteric attachment, and covers the raw surface and the packing with peritoneum.

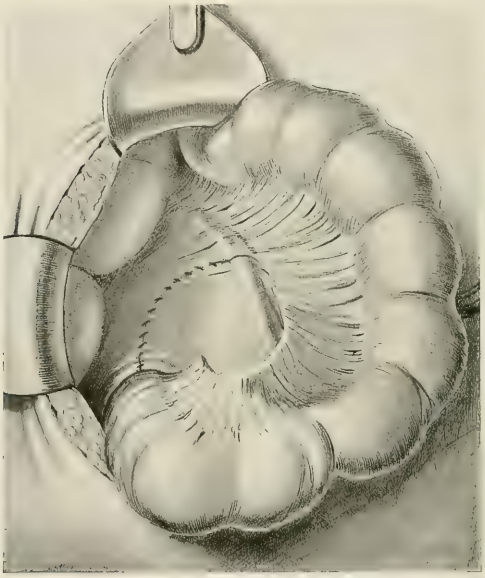


FIG. 1510.—ABDOMINOSACRAL PROCTECTOMY.

The sigmoid mesentery has been divided and the peritoneal flap sewed over the pelvis and about the rectum. All of the segment of bowel which has had its mesentery divided is really to be drawn down into the pelvis.

The sigmoid is then divided, with the cautery between two encircling ligatures. All exposed mucous membrane is sterilized by the cautery point and iodin (Fig. 1511). The lower stump is inverted into itself and pushed down beyond the peritoneal covering into the pelvis. It disappears and the peritoneal suture is continued over the opening. This inversion of the lower sigmoid into the rectum may be done entirely from above, or a large rubber catheter may be passed from below through the rectum and the end caught with a ligature, passed through its eye in a needle, and tied. Traction on this tube inverts the stump of sigmoid into the rectum.

The upper sigmoid stump is then brought out through the abdominal wound and sutured into position for a permanent artificial anus (see Artificial Anus, Vol. II, page 687).

From two to seven days later an incision is made around the anus and carried back to the sacrum. The anus and coccyx are excised; and the rectum removed. The gauze and rubber dam around the rectum have left a barrier of granulations, and infection is not apt to occur. The great wound remaining should be sutured as far as possible and a drainage tube and gauze packing introduced.

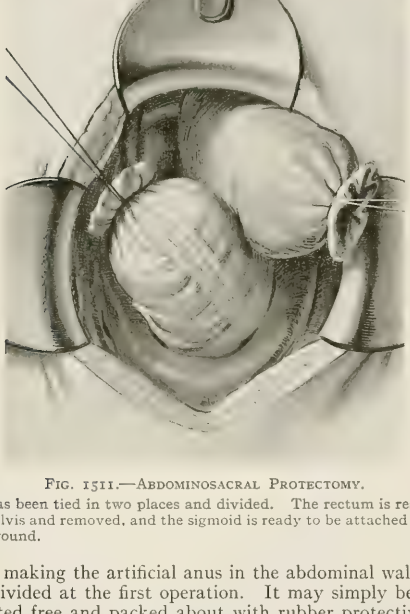


FIG. 1511.—ABDOMINOSACRAL PROTECTOMY.

The bowel has been tied in two places and divided. The rectum is ready to be drawn down into the pelvis and removed, and the sigmoid is ready to be attached at the anus or in the abdominal wound.

Instead of making the artificial anus in the abdominal wall, the sigmoid need not be divided at the first operation. It may simply be isolated, the rectum dissected free and packed about with rubber protective and gauze, the peritoneal diaphragm sutured between the pelvis and abdomen, and the abdomen closed. At the end of five days the rectum is removed from below. As this is done the sigmoid is drawn down through the peritoneal diaphragm, and sutured at the anus. If the cancer is low in the rectum the anus should be removed with the bowel (Fig. 1229). After amputating above the rectum, the bowel may be made fast to the wound by any of the methods described for the one-stage low operation. Between the two operations, the possibility of gangrene of the isolated segment of bowel should be had in mind.

If the cancer is high the anus may be left. In the latter event, the incision is made between the anus and sacrum, the coccyx removed, and the

rectum divided just above the anus. If the tumor mass is not large this may be done by inverting the rectum through the anus. The sigmoid is then sewed to the anal opening.

For high cancer an operation for *resection of the rectum with preservation of the sphincter ani*, may be done which possesses all the advantages of the above-described operations. This operation is applicable in cases of cancer in which the place of the distal section is not nearer than 6 cm. ($2\frac{1}{2}$ inches) to the sphincter ani. The operation begins with the steps of the abdominal operation. The rectum is freed from above, the lower sigmoid pressed down into the pelvis, the peritoneum sutured across, and a left inguinal colostomy done. At the second operation the rectum is isolated from below by the

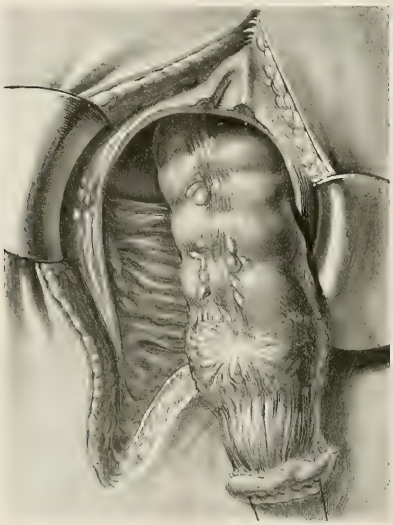


FIG. 1512.—ABDOMINOSACRAL PROCTECTOMY.
The anus has been closed by a continuous suture of heavy thread, and the anus and rectum dissected free and ready for amputation.

steps described in the operation for resection of the coccyx and part of the sacrum. It is drawn down, amputated at least 6 cm. above the sphincter, and the diseased segment removed. The stump of bowel is then drawn down and sutured to the distal segment. The proximal part is much smaller than the lower part, and must have its caliber increased by oblique incision or by two lateral incisions.

Comment.—The best operation for cancer of the rectum is the two-stage procedure which leaves an artificial anus in the abdominal wall and makes a wide removal of the rectum, anus, perirectal, and subperitoneal connective tissue and lymphatics. Cancer of the rectum is a serious disease, and to strive for a restoration of the anal function at the sacroperineal outlet is apt to sacrifice chances of a cure. The preservation of the natural anus

after removal of the rectum is of very doubtful expediency. Usually its nerve supply must be destroyed and its function is not as good as that of an abdominal anus.

Recurrences commonly take place about the anus when the anus is preserved. If the lower opening is maintained, at least all of the mucous membrane and adjacent tissue should be removed out to the skin, and only the surrounding muscle left.

Infection is the immediate danger after the one-stage operation for removal of the rectum. The large raw surface in the pelvis is the great hazard. By doing the two-stage operation, and packing with rubber dam and gauze a lining of granulation tissue is secured before the pelvic cavity is exposed to its greatest danger. This is a most important step in the operation.

The second operation may be done with spinal subarachnoid anesthesia if the patient objects to a second general anesthetic. It is possible to do it with local infiltration anesthesia. It is but a slight operation.

Ligation of the two internal iliac arteries may be done at the first operation to save blood if it is thought best, but a careful technic demands nothing more than ligation of the inferior mesenteric.

A combination of any of the above methods of proctectomy may be made.

After proctectomy, if inguinal colostomy has not been done, union of the sutured bowel end will be more certain if the bowels are not evacuated for a week. Constipation may be secured by a small amount of opium. The patient should have a diet chiefly of milk.

The *palliative treatment* of inoperable carcinoma of the rectum is often required. The most important palliative measure is left inguinal colostomy. It is surprising to see how a patient suffering with the effects of septic absorption, hemorrhage, constipation, and cancer cachexia improves as soon as the constant irritation of fecal matter is removed from the rectum. The growth often seems to undergo retrogression, and the patient may live on in a fair degree of comfort for months or years. Other local measures are described under the general treatment of cancer (Vol. I, page 327).

THE VERMIFORM APPENDIX

Anatomy.—The vermiform appendix usually hangs free in the peritoneal cavity, being attached above to the cecum and behind to its mesoappendix. Its average length is 9 cm. (3.5 inches).

The mesentery of the appendix is continuous with the lower leaf of the mesentery of the termination of the ileum. Between its layers are the appendicular artery and its branches, veins, nerves, lymphatics, and some small lymph-nodes (Fig. 1513).

The artery is a branch of the posterior ileocecal, and runs in the free border of the mesoappendix to the tip of the organ. It anastomoses with the cecal artery by branches which are so small that the appendical artery may be regarded almost as terminal.

The appendix has a lumen of very variable caliber. As age advances it tends to become obliterated. It opens into the cecum about 2.5 cm. (1 inch) from the ileocecal valve.

A line drawn from the anterior-superior spine of the ilium to the umbilicus in a young adult crosses the outer edge of the rectus muscle about 6.5 cm. (2.6 inches) from the anterior-superior spine. Directly behind this point is the ileocecal valve. The appendix

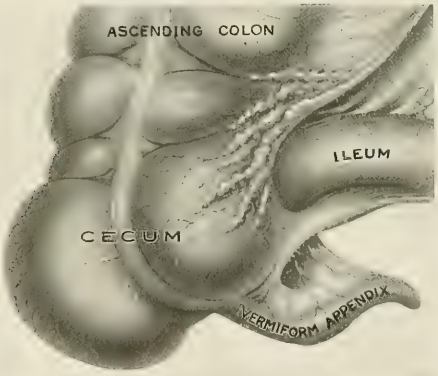


Fig. 1513.—The Vermiform Appendix and Its Intestinal Connections.

joins the cecum about 2.5 cm. (1 inch) below this point. This means that in the average case the root of the appendix is at a point somewhat more than 2.5 cm. (1 inch) below and external to the middle of the ilioumbilical line. This is quite variable.

Upon opening the abdomen, the appendix is located by following the peritoneal lining of the abdomen from the outer edge of the wound outward, to the flank, and thence inward to the cecum. The cecum having been identified, it will be seen to present the continuations of the three longitudinal bands of the colon; the anterior of these when followed downward upon the cecum will be found to lead to the appendix. When searching for the appendix from within outward, the ileocecal junction is the landmark.

If the appendix is not easily found, the difficulty may be because it is buried by adhesions—old or new; it may be herniated into one of the pericecal fossæ; it may have entered an inguinal or femoral hernia; it may have been destroyed by previous inflammation; it may have been removed at some previous operation; or it may be congenitally absent.

APPENDICITIS

The **prophylaxis of appendicitis** is a matter of considerable moment. The blood supply of the appendix is so at the mercy of the single appendicular artery, that unless the circulation goes on undisturbed danger is threatened. Constipation is a potent factor in causing appendicitis. Fecal masses causing pressure upon the vessels at the root of the appendix should be avoided. Constipation is, perhaps, also a factor by causing the retention of infective matter in the lumen of the appendix.

The appendix being so largely a lymphatic structure, it is subject to the same infections as enter through the tonsils. Diseased tonsils and adenoids predispose to the disease, and should be cured as a prophylactic measure. The same may be said of infections of the teeth and tooth sockets, gall-bladder infections, and ulcers of the stomach and duodenum. The prophylaxis of these invasions is best secured by maintaining a good general resistance and an avoidance of the presence of the causative organisms. There is something of a community or geographic distribution of the disease, as it seems to be more common in cities than in the country. As a strange fatality, it seems to be most prevalent in surgical centers.

Traumatism to the appendical region should be avoided as this is probably capable of acting as a causative agent (J. P. Warbasse, "Traumatism as an Etiologic Factor in Appendicitis," New York State Jour. of Med., August, 1908).

As the disease is most prevalent in persons between the ages of five and thirty years of age, and in those who are particularly disposed to tonsillitis and so-called arthritic disease, these ages and conditions should receive especial consideration.

As the victims of appendicitis are often large consumers of meat, and as a vegetable diet makes for immunity, this should be considered. Patients who live on farinaceous foods, legumes, macaroni, butter, milk, and cheese, with a plentiful proportion of green vegetables, and who do moderate and systematic work in the open air, are least subject to the disease. Alcoholic drinks predispose to appendicitis.

An appendix which has once been the seat of inflammation is apt to remain permanently damaged, and prone to subsequent attacks. It may always remain a menace, and its removal is the only guarantee of immunity.

At health resorts and in doctor's offices are numbers of patients occupied in carrying out the prophylactic measures against appendicitis. They have had chronic attacks or an acute attack which has left rumblings of direful possibilities. Fearful of the disease, they go about with a maximum of appendicitis in their minds and a modicum in their bellies. These people need operation, as the best hope of restoring their efficiency and happiness. They are infinitely better off forever scarred than forever scared.

From what is known of the subject, it may be said that the best prophylaxis is secured by maintaining the bowels in a not overloaded state, by a diet containing but little meat, by good general resistance and by simple rustic life, with methodical work in the open air.

Remarks on the Treatment of Appendicitis.—The discussion of the treatment of the disease will be according to the clinical character of the attack, which can be seen, rather than according to the anatomic conditions, which cannot be seen but only surmised. In no field of surgery is the French proverb more applicable: "Un bon opérateur serait quelquefois un mauvais churgien."

I desire to repeat a statement, made some years ago, which has been adversely criticised: most cases of appendicitis recover without operation.

This number is, perhaps, 75 per cent. of cases in this country. It should not be taught that every case of appendicitis must be operated upon in order to save the patient's life (J. P. Warbasse: "Cases of Appendicitis Which Do Not Demand Operation," Long Island Med. Jour., March, 1907).

The position of surgery should be this: while it is true that most cases of appendicitis will recover without operation, in competent hands operation has so little hazard, the dangers of the disease are so great, and its course so uncertain, that operation should be the rule when a competent surgeon can be secured; but to promulgate the doctrine that every case of appendicitis should be operated upon is not justified by the facts inherent in the pathology of the disease, nor is it justified by the skill in surgery possessed at present by all licentiates of medicine. When the skillful and well-equipped surgeon reports that there is no mortality among his cases operated upon during the first twenty-four hours, this is in no sense a criterion of the results which would follow the teaching that every case, if possible, should be operated upon during the first twenty-four hours. There is a surgical hazard as well as a pathological hazard.

In a patient with a mild attack of appendicitis, or with an attack under circumstances which ordinarily would not call for operation, if he is about to undertake a journey in which he will be remote from competent surgical aid, operation is more urgently called for. This is because of the danger of recurrent attacks.

Nonoperative treatment is indicated when a competent surgeon can not be had; when materials and place for operation are not accessible; when the condition of the patient should not permit operation; when the patient will not permit operation; when the attack is the first and of an extremely mild type (catarrhal appendicitis or appendical colic without submucous inflammation), and occurring in a patient who does not command the highest surgical skill or who later will be accessible to surgical skill; and when an attack of a mild type is distinctly subsiding after the first forty hours.

The nonoperative treatment requires first that the patient shall be kept quietly in bed. In an acute attack, coming on suddenly, the stomach should be washed out to minimize as much as possible the amount of food to pass through the bowel. Even though operation is to be done, this is desirable. Within the first six or twelve hours of an attack, a full dose of castor oil may be introduced through the stomach tube after the lavage. This is so early in the disease that the peristalsis excited can probably do no harm.

But after twelve or twenty-four hours the inhibition of peristalsis is desirable. This is best accomplished by keeping the stomach empty, and resorting to enema to move the bowels. Ochsner has shown that the ingestion of fluid diet or even of water is undesirable (see Treatment of Peritonitis, Vol. II, page 546).

The lower bowel should be emptied by simple warm enemata. Nutrient enemata should be depended upon for sustenance (Vol. II, page 620). Fluids are best introduced into the system by proctoclysis (page 55). Pain may be relieved by codein or the ice-bag. Nausea calls for washing out of the stomach.

The use of serum and vaccine of colon bacillus in the earliest stage of the disease before the pain becomes localized is of value. The serum is given in a 20 c.c. dose, and a few days later 100,000,000 colon bacillus vaccine is given to prevent recurrence. This treatment has given good results in the hands of Guthrie (Lancet, London, Jan. 9, 1915).

Pre-operative Treatment and Indications for Operation.—Provided a competent surgeon operates, acute appendicitis should be operated upon as soon as possible. This should be during the first twelve, eighteen, or twenty-four hours. In some cases thirty-six hours or more may elapse before the infection extends beyond the appendix. Operation should be done, if possible, while the disease is still confined to that organ.

After the peritoneum has become invaded, the circumstances are altered. In these cases also the skilled surgeon should operate at once, excepting in moribund cases. The operation should be quick and with the least possible handling and moving of the intestines. The spreading of the infection to new areas of peritoneum is the great danger. Unless the surgeon can avoid this the patient will have a better chance of recovery under the nonoperative treatment as advised by Ochsner for peritonitis.

In the absence of skillful surgery, in acute cases in which infection has extended beyond the appendix, gastric lavage, rest, and the absolute withholding of food and drink by mouth should be relied upon; operation should not be done until the acute infection has subsided, or definite local conditions, such as walled-off abscess, call for operation.

The fasting treatment in these unoperated cases should be continued until the patient has been without pain for four days.

Thirst should be quenched by small enemata or proctoclysis.

The first water given should be teaspoonful doses of hot water.

Cathartics should not be given, if no operation is done, until the patient has been free from pain for four days.

Foods, fluids and cathartics excite peristalsis, and are the great danger in acute attacks.

It should be understood that the treatment worked out by Ochsner is not a nonoperative treatment. It is (1) a treatment made necessary by neglect or inability to perform timely operation and (2) a preparation for deferred operation at a more propitious time.

Under this treatment, a large majority of attacks of appendicitis will subside, whether they belong to the category of nonoperative cases or not. It is the fact that a certain number of cases will develop perforation, gangrene or diffuse septic infection, and that these accidents can with certainty neither be predicted nor prevented, that renders operation in competent hands the treatment of choice even in the apparently mild cases.

If operation can be done in acute cases before pus has formed there should be no mortality. This should be the aim of surgery.

The administration of food and fluids by mouth should be prohibited in all acute cases.

The stomach should be washed out if nausea or vomiting are present.

Large enemata should not be given. They are dangerous in acute attacks.

Gaseous distention of the bowel should be relieved by gastric lavage.

Chronic recurring appendicitis should be operated upon between attacks.

It is to be borne in mind that, whatever may be said to the contrary, there are many conditions capable of being confused with appendicitis in its early stage. Catarrhal inflammation of the cecum and pressure of fecal material at the base of the appendix are benefited or cured by lavage, laxatives and abstinence from food by the stomach. Undoubtedly many such cases go to swell the statistics of cases cured by nonoperative methods. Sonnenburg (Therapie der Gegenwart, Bd. xlix, No. 2, S. 49) gave castor oil in early cases suggesting appendicitis, if the pulse is not above 92, temperature 37.5°C (99.5°F.), and leukocytosis 15,000. He operated immediately if there is not improvement at once after the purge has taken effect. This

treatment should be considered only during the first six hours; it should not be carried out by any one but the surgeon; and the preparations for operation should be at hand from the beginning.

Operative treatment is best applied within the first thirty-six hours of the attack—to be on the safe side within the first twenty-four hours. This is called the *first stage* of the disease. In most cases requiring operation the diagnosis can be made within this time. By such an early operation the appendix is removed before preforation has occurred; the infection has not yet penetrated to the peritoneum; the patient has not yet become depressed by toxemia; and the disease is still localized in the interior of the organ. By removing the appendix at this stage, an aseptic operation is done, complicating adhesions have not formed, no drainage is required, the abdomen is closed in such a manner as to avoid hernia, and the period of convalescence need not be longer than after any other aseptic abdominal operation. The danger of operation is scarcely greater than that of any simple intra-abdominal manipulation. There should be no mortality.

Operation in the *second stage* of the disease, when the inflammation has reached the peritoneum, is a much more serious matter. There is peritonitis involving at least the covering of the appendix and the peritoneum with which it is in contact. It is fortunate if this be all. There may be an abscess confined about the appendix, or, if limiting adhesions have not formed, a spreading suppuration may exist. Gangrene, perforation, spreading peritonitis, or spreading general infection may be found. The patient may be seriously depressed with toxins. Intestinal paresis may be superadded. It is in this stage of the disease, between the second and seventh day, that operation is a most serious matter. But it is so only because the condition of the patient has become serious.

In the absence of the conditions essential for successful operation, the best treatment at this stage is that described as the fasting treatment for peritonitis (Ochsner). This is the treatment which often should be applied as a preliminary to operation which may later be necessary. But in some cases, the exigencies of the situation require immediate operation. An abscess may already be present. Perforation may be aggravating peritonitis. Adhesions, angulation, or intractable sepsis may threaten life. Or the present may for some other reason be the opportune time for operation.

Under these circumstances operation at this stage, should be directed to the removal of the appendix, or to the drainage of the chief focus of infection, or to meeting any other emergency with the least possible manipulation or disturbance of the neighboring structures. Nature is endeavoring to check the infective invasion by throwing out barriers of adhesions; these should not be destroyed. If the appendix is easily accessible and can be isolated without breaking down important adhesions, it may be removed. If its removal means much blunt dissection, manipulation, abrasion, and breaking of adhesions, a drain should be carried down to it, and it should be left. The unperforated appendix, lying in a bed of adhesions, without abscess, can be removed with less danger. Sponging and irrigation should be avoided. Pus retained under tension should be liberated by incision, aspirated, and a drainage tube inserted. No more should be done.

The safest operation is that which goes directly to the main focus of infection, drains, and ends without traumatism anywhere except in the line of the drainage tract. The operation should be short and simple. The surgeon should not be tempted in this dangerous stage to do too much.

So easy is it to turn the balance against the patient by operation in this second stage that Ochsner applied the rest treatment to these cases with

results which surpassed those secured by immediate operation. The intelligent application of the methods of Ochsner requires skill and judgment; but there are more doctors capable of its intelligent application than there are surgeons capable of the best discrimination and possessed of the best skill in operating on appendicitis in the stage of spreading infection. If the skillful surgeon is to be had, operation is the treatment of choice. But on the whole, if all of these cases were treated according to Ochsner, and operation deferred until it becomes a simple matter, the best results would be secured.

Many cases in this second stage early show signs of subsidence of the disease. Shall operation be done while there is a steady improvement in the general conditions and abatement of the local symptoms? So long as the patient is under close observation, and operation can be performed upon short notice, it is best to continue the nonoperative treatment until all symptoms have subsided. Then, if there have been previous attacks, or if the patient elects operation, the appendix may be removed.

On the other hand, the symptoms may not subside, but under the treatment by rest abscess may form. In this event, the abscess should be opened and drainage provided after the acute stage has passed, the operation being made as simple and direct as possible, preferably under local anesthesia. Several such operations may require to be done; but it may be expected that ultimately the infective process will subside.

Organized adhesions are usually formed in five days or a week, and by this time the diet by mouth may begin. Up until then, nutrient enemata should have furnished the subsistence, unless the symptoms have already markedly subsided.

The *after-treatment* of these cases, as well as the rest treatment, is best carried out with the patient in the semi-upright position. Large quantities of fluid should be given by rectum. This sitting position causes pus to gravitate where drainage can be better accomplished. It should be maintained when the patient has to be transported.

The *third stage*, that of subsidence of the infection and circumscription of the disease, requires operation only for the drainage of pus. Often the suppurating focus heals itself by absorption or evacuation into the bowel. It is best not to defer operation until this has occurred. Spontaneous healing is dangerous because thrombophlebitis, rupture into the uninfected peritoneum, or lymphatic infection is apt to occur. Simple and direct evacuation of the abscess without disturbing the adhesions is best. If rupture into the general peritoneal cavity has taken place, to the treatment of the abscess should be added that of spreading peritonitis.

An unfortunate result of treatment of abscess alone is that the appendix is left in the abdomen. While in most of these cases of suppuration the appendix has become so disorganized that it is practically destroyed, still in very many cases enough appendical tissue remains to make trouble. If the appendix is not removed the patient may have subsequent attacks, or, what is more common, he may suffer from vague abdominal and reflex nervous disturbances which will persist until the relic of the appendix is taken out.

The *fourth stage*, is that following an acute attack, in which infection has subsided and no abscess remains. Adhesions and an infiltrated appendix may have been present. The adhesions are absorbed or contracted and the infiltration has subsided. The patient may be entirely free of symptoms; and it may be said that the disease no longer exists. He is well. Is operation now indicated? If the patient has had but one attack, and lives within easy access of surgical skill, no operation need be done after recovery without operation from a first attack. If the patient has had two or more attacks,

after all symptoms have subsided, operation should be advised. If the patient is going on a journey out of the reach of surgical skill, removal of the appendix is best. Very commonly, although the attack seems to have subsided, the patient continues to suffer with vague disturbances of digestion, constipation, nervous irritation, loss of weight, malaise, or possibly vague sense of abdominal discomfort. Under such circumstances removal of the appendix is indicated if no other cause can be found, and it will commonly be discovered that the angulated, adherent, or partly disorganized appendix was the cause of the disturbance.

Many patients, with a history of attacks of acute appendicitis many years before, suffer with confusing symptoms of pain, discomfort, cramps, inability to sleep after eating, loss of weight, abdominal tenderness, or symptoms referable to the stomach, gall-bladder or other organs—one or more of these vague ills—are relieved only after the operative removal of a chronically inflamed appendix. In my own case, I suffered three or four acute attacks of appendicitis and forgot about them. Twenty-five years later the removal

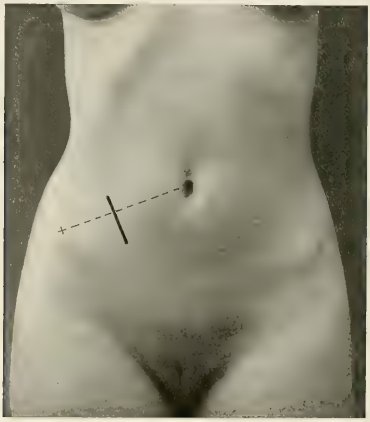


Fig. 1514.—Oblique Incision for Exposure of Vermiform Appendix.

of an appendix, bound down in old adhesions behind the cecum, relieved symptoms of discomfort which seemed referable to the gall-bladder and stomach.

Technic of Operations for Appendicitis.—*In the first stage* of an acute attack, before the disease has reached the peritoneum, the abdomen is opened by a 7.5-cm. (3-inch) incision, having its middle about opposite the ileocecal valve, and running downward and inward in the direction of the fibers of the external oblique muscle (see Preparation for Abdominal Operations and Operations for Entering the Abdomen. Vol. II, pp. 499 and 504) (Fig. 1514). This incision should be crossed just above its middle by a line connecting the umbilicus and the anterior-superior spine. The incision crosses this line about 1.3 cm. (½ inch) external to the middle of the line. About one-third of the incision lies above the line. The incision should be through the skin and superficial fascia down to the external layer of the deep fascia (Fig. 1515).

The fascia lying in front of the oblique muscle should be incised as far as the border of the rectus muscle. The fibers of the external oblique are split by

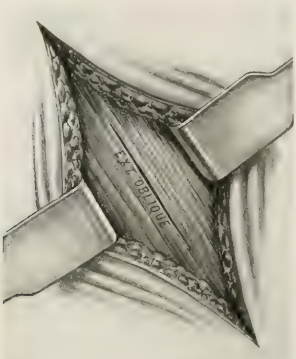


FIG. 1515.—EXPOSURE OF APPENDIX. FIRST STAGE.
The skin has been incised and the fibers of the external oblique muscle exposed. An incision is made between the fibers of the muscle.

blunt dissection with the handle of the scalpel and retracted (Fig. 1516). The internal oblique fibers, running more nearly horizontal than the external

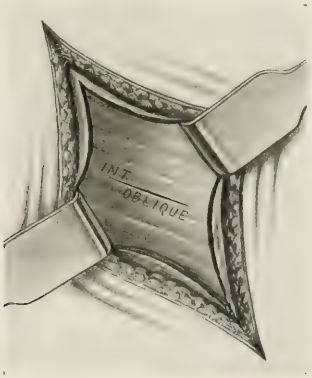


FIG. 1516.—EXPOSURE OF APPENDIX. SECOND STAGE.
The fibers of the external oblique muscle have been separated and are retracted, exposing the internal oblique muscle. A small incision is made in the latter.

oblique should be treated in the same way. The transversalis fascia and peritoneum should be incised in the direction of the skin incision (Fig. 1517).

It will be observed that about 2.5 cm. (1 inch) of the skin incision lies in front of the rectus muscle. During the progress of the operation, if it is

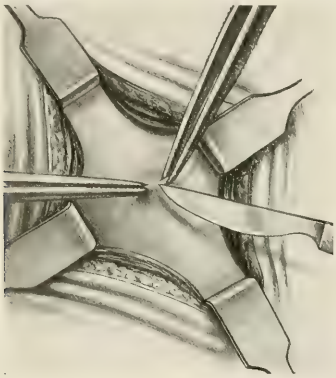


FIG. 1517.—EXPOSURE OF APPENDIX. THIRD STAGE.
The fibers of the internal oblique and transversalis are separated and retracted, exposing the transversalis fascia and peritoneum, which are picked up and incised.

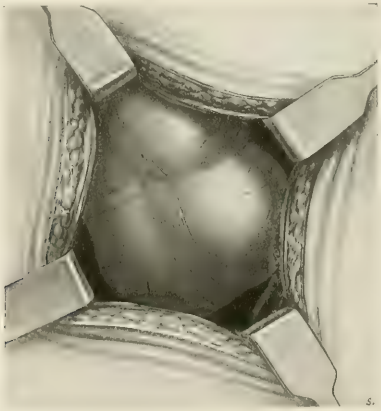


FIG. 1518.—EXPOSURE OF THE APPENDIX. FOURTH STAGE.
The peritoneum is opened and retracted and the cecum appears at the wound. By following the cecum downward the appendix is reached.

retracted. If there is a possibility of more room being required it is best to make the first incision through the transversalis fascia and peritoneum in the line with the opening through the internal oblique and transversalis muscles. Then the rectus sheaths may be divided by continuing this incision along with the incision of the peritoneum in a line continuous with the opening already made. Usually in early cases, it will be found that the intramuscular opening external to the rectus suffices. The elasticity of the abdominal wall is so great that the size of the opening is regulated by the amount of traction applied by the four retractors. In cases in which the chief tenderness is internal to the usual position the incision should be nearly vertical, and bisected by the line connecting the navel and anterior-superior spine of the ilium. This incision lies just internal to the outer edge of the rectus. The rectus muscle should be exposed, retracted inward and the abdomen opened through its posterior sheath.

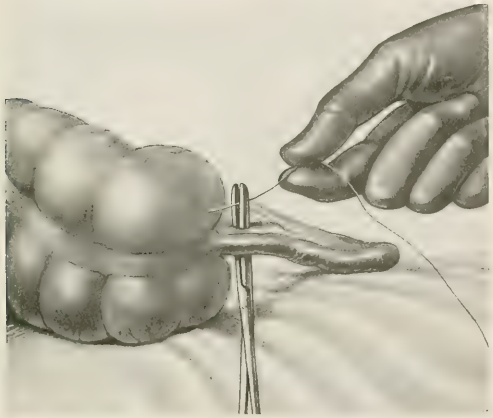


FIG. 1519.—REMOVAL OF THE APPENDIX. FIRST STAGE.
The meso-appendix is transfixed with a clamp, and a ligature carried through it.

As the peritoneum is opened and retracted the cecum usually presents at the wound (Fig. 1518). The appendix is easily located below it.

The appendix is located by inserting two fingers into the wound, passing them outward in contact with the anterior abdominal wall, thence following the wall around to the mesentery of the ascending colon. This being felt, the fingers pass down to the cecum, and to the root of the appendix. The intestines are packed off with a flat sponge, and pressed inward and upward. The appendix is brought into the wound with the fingers. If it is swollen and tense, care should be taken not to rupture it. The meso-appendix should be grasped, and transfixed by a catgut ligature close to the junction of appendix and cecum (Fig. 1519). This ligature should be tied.

A purse-string suture is then applied to the caput coli around the base to the appendix. This puckering string should be about 1 cm. ($\frac{1}{3}$ inch) away from the appendix (Fig. 1520). The base of the appendix should be

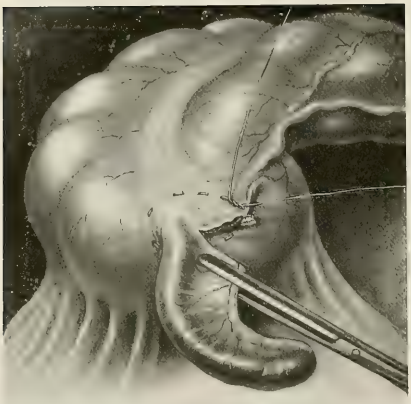


FIG. 1520.—REMOVAL OF THE APPENDIX. SECOND STAGE.
The meso-appendix has been tied and divided, and the purse-string suture has been inserted in the cecum around the base of the appendix.

FIG. 1520a.—LIGATURE OF APPENDIX AND MESO-APPENDIX.
Showing ligation with a single thread.

bluntly stripped of fat, and the same ligature which was used to tie the meso-appendix, or a separate catgut ligature, tied about it 7.5 mm. (¼ inch) from the cecum. Fine, plain catgut should be used for ligating the appendix (Fig. 1520*a*) and chromic catgut for the purse-string suture.

A clamp should be applied to the appendix 7.5 mm (¼ inch) beyond the ligature, and the appendix amputated just above the clamp (Fig. 1521). The appendix is amputated best with scissors. Some surgeons use the actual cautery, and at once sterilize the mucous membrane, lining the stump beyond the ligature, by touching it with the cautery. Crushing the base with the angiotribe is effective. Before cutting the appendix a sponge should be placed beneath it to catch any of its contents which are dropped.

The amputated appendix with the clamps and the scissors or knife employed in the amputation are laid aside as infected material. The stump

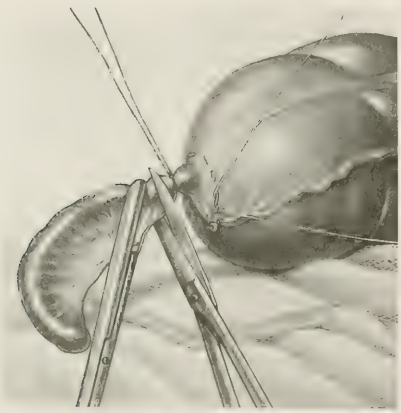


FIG. 1521.—REMOVAL OF APPENDIX. THIRD STAGE.
Appendix has been tied and is about to be amputated. A gauze sponge is placed under it to catch any of the contents that escape.

is caught close to the cecum with a fine mouse-tooth clamp to hold it. Its ligature ends are cut off. A fresh pad is laid over the adjacent structures. With previously prepared wooden toothpicks or match stems, wound at the ends with a small spindle of absorbent cotton, the mucous membrane of the interior of the stump of the appendix is sterilized with tincture of iodin, pure phenol; or it may be sterilized with the actual cautery. This is an important step in the operation and should not be slighted.

The purse-string suture is then tied down as the clamp supporting the stump is removed. As the suture closes above the stump, the latter should be pressed in by means of the clamp (Fig. 1522) or the eye-end of a curved needle slipped under the suture. The stump sinks from view, and its place of burial is marked by a dimple. The ligature is tied and cut.

The treatment of the ligated stump of meso-appendix should vary with its size. If small, it may be included in the purse-string suture and buried with the stump of the appendix. If larger, it should be buried by a couple

of fine sutures, sinking it under the peritoneum on either side (Fig. 1523). If the saving of time is necessary, it need receive no further attention. If the appendix has been tied with the ends of the same ligature which was used to tie the meso-appendix, the stump of the meso-appendix follows the stump of the appendix and is buried by the purse-string suture.

It is not necessary to use *drainage* in cases in which the infection is confined to the appendix. If there is some plastic exudate about the appendix, causing it to adhere to the neighboring peritoneum, or if a small amount of serous fluid is present, drainage is not necessary so long as the appendix is not perforated. (For Closure of the Abdominal Wound, see Vol. II, page 516.)

In cases in which greater expedition is necessary, the purse-string suture about the appendix need not be applied. If the meso-appendix is tied and cut, the appendix tightly ligated at the base with chromic catgut, amputated 3 mm. ($\frac{1}{8}$ inch) beyond the ligature, and the mucous membrane of the stump

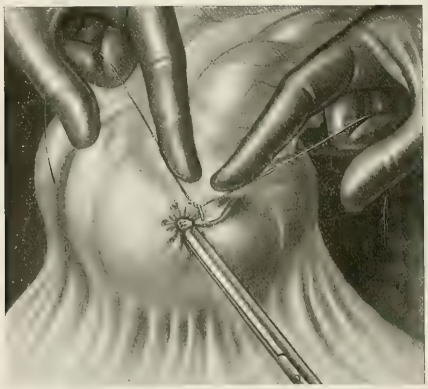


FIG. 1522.—REMOVAL OF APPENDIX. FOURTH STAGE.
Tying purse-string suture and pressing stump in with a clamp so that it shall be buried beneath the suture.

sterilized, the danger of perforation is inconsiderable. The main object in burying the stump is to prevent adhesions. Serious leakage has occurred when the ligature was not well tied, and gas or fluid distended the cecum; and cases have been reported in which adhesions to the stump have caused angulation and obstruction. A still more rapid operation consists in tying appendix and meso-appendix in the same ligature of chromicized catgut, cutting off the appendix and sterilizing the mucous membrane of its stump with the actual cautery, and closing the abdomen.

Appendicitis with circumscribed abscess located at the appendix is the most common result of the cases which are not operated upon in the first stage and which do not go on to healing. During the first four or five days the adhesions between the coils of intestines are very soft and delicate. Great care should be exercised in moving and examining the patient lest they be broken, and the infection spread to uninvaded peritoneum. Pressure upon the abdomen, rolling the patient from side to side, and muscular efforts on the part of the patient should all be restrained or interdicted.

Unless the abscess is incised, there is a strong probability that it will evacuate itself spontaneously into a viscus or through the abdominal wall. In preparing the patient for operation care should be used to prevent struggling under the anesthetic. An incision should be made in front of the center of the tumor or induration. This should be an intramuscular incision just as for operation in the first stage. As the peritoneum is approached, the overlying tissues often will be found infiltrated with serum. Upon opening the peritoneum pus may gush forth at once, or the separation of some adhesions in the direction of the appendix may be necessary before it is discovered.

If the abscess is not entered at once the surrounding peritoneum should be kept well protected by packing with gauze pads. The pus should be allowed to escape and be taken up gently with sponges. Retraction should be carefully made, and the cavity sponged dry. If the appendix is free in the cavity or easily accessible it may be ligated and removed. No purse-

FIG. 1523.—REMOVAL OF APPENDIX. FIFTH STAGE.
Result of operation.

string should be applied. If it is deeply buried in adhesions, the breaking of which may open up uninfected areas, it should be left undisturbed. The greater skill and the more experience the surgeon has the more is he justified in removing appendices under these circumstances. The occasional operator should not attempt the removal of the appendix from the wall of an abscess.

In ligating the appendix, it is only necessary to throw a ligature of chromic catgut around its base and amputate it. The meso-appendix is embraced in the same ligature. If the stump is easily accessible its mucous membrane may be sterilized with iodin.

A good-sized drainage tube should be placed at the stump and fastened in the wound. A narrow strip of wick or gauze drain should also be placed through the abdominal wall on either side of the tube. Or a large split rubber tube, containing wick or gauze may be used. The abdomen is closed by layer sutures as in the operation without drainage, the sutures being brought as far as the drains and there tied (see Vol. II, page 524).

In the event of *rupture of the abscess* into the general peritoneal cavity

the surgeon will often observe that the tumor has become less tense; when the abscess is opened the pus does not escape as though under pressure; and further search shows clean peritoneum bathed in pus. The pus should gently be sponged away. Irrigation is to be deprecated, as it is apt to spread the infection. It is not essential that every drop of pus should be removed. Besides the drainage provided for the abscess cavity, a tube and gauze or wick should be placed in the center of the newly infected area. It will commonly be found that such secondary infection finds its way into the pelvis; and it will generally be advisable to place the drain in the prerectal cul-de-sac.

When there is *abscess in an unusual position* the drainage may be adapted to the peculiarities of the case. In the female an appendix hanging over the pelvic brim may cause abscess in the cul-de-sac which is best drained by making an opening through the posterior fornix of the vagina. An abscess lying external to the mesentery of the cecum and ascending colon is best drained by an opening in the flank.

In these cases after having removed the pus and either amputated the appendix or determined to leave it undisturbed, the counter-opening is made, the drainage tube inserted through it, and the anterior abdominal wound is closed. If there has been no fresh peritoneum exposed, no drainage need be used in the anterior abdominal wound. Abscesses in the region of the liver should not be drained through the pleural cavity unless the pleura already has become infected with the same organisms.

Appendicitis with diffuse suppurative peritonitis should be operated upon as soon as possible with the least shock to the patient that can be secured (see Peritonitis Vol. II, page 546). A general anesthetic is dangerous in cases with much depression. But little ether should be used. Local anesthesia is often to be preferred. Everything should be in readiness to proceed with the operation before the anesthetic is begun. The abdomen should be opened by a nearly vertical incision, bisecting and bisected by a line connecting the navel and anterior-superior spine. The anterior sheath of the rectus muscle should be opened near its outer edge, the outer edge of the muscle retracted inward, and the abdomen entered through its posterior sheath.

The next step in the operation should consist in going directly for the appendix. It should be ligated and removed. A good-sized drainage tube should be placed at its stump. Another large tube should be placed in the prerectal pouch. If rubber tubes are used they should be fenestrated and stiff enough not to collapse. Each tube should contain a loose strand of wicking.

This operation should be done with expedition. The least possible traumatism should be inflicted. The intestines should not be handled. No effort should be made to sponge away the pus except as is necessary to make the appendix visible. Pus should be removed by means of the continuous suction apparatus. A couple of silkworm-gut sutures should close the wound about the tubes.

The next important step is that the patient should be placed in the elevated head position. The trunk should be placed on an incline of 35 or 45 degrees above the horizontal. Proctoclysis and the fasting treatment of Ochsner should be instituted. The chief causative organism may be determined, and vaccine administered (see Diffuse Suppurative Peritonitis, Vol. II, page 548).

Perforative appendicitis and *gangrenous appendicitis* require the treatment described above for the conditions which they produce. It may be said

in general that the sooner the infected area is provided with drainage, the better hope for recovery is secured for the patient, provided a direct operation is done without disturbance of the surrounding intestines. *Fulminating, acute gangrenous* and *perforative appendicitis* demand immediate operation, and represent the class of cases in which delay, even during the first few hours, may be fatal.

Subperitoneal appendicitis is that form in which the appendix instead of being free in the peritoneal cavity is buried under the peritoneum, as a result of retroperitoneal hernia, congenital retroperitoneal development of the appendix, or adhesions, and requires the same treatment as that described above. Less urgency is demanded because of the confinement of the appendix, but operation should be done in the first stage of the disease.

Left-sided appendicitis is not so unusual but that the surgeon should have it always in mind. Whether due to non-rotation of the colon or elongated appendix, it requires the same operation on the left side as the ordinary appendicitis does on the right.

Typhoid appendicitis should be treated the same as typhoid. Appendicitis occurring in a typhoid patient should be treated the same as appendicitis. *Typhoid ulcers* of the appendix should be treated as typhoid; when they perforate they should be treated as perforating appendicitis.

Tuberculous appendicitis should receive the same treatment as described for tuberculosis of the intestines and peritoneum (Vol. II, pages 574 and 554).

Removal of the appendix in the quiescent stage is called the *interval* or *intermediate operation*. It is performed after the symptoms of an acute or subacute attack have subsided. There may or may not be remaining some suggestion of appendical disturbance. The abdomen should be opened by the incision bisecting and bisected by the umbilical spinous line. The incision should be parallel with the outer border of the rectus and just internal to it. The anterior sheath should be opened, the muscle retracted inward, and the abdomen entered through the posterior sheath. Some adhesions are usually found about the appendix. These are divided. They rarely are so vascular as to require ligatures. The appendix is dissected free, ligated, amputated, and its stump buried by a purse-string suture or its like.

The appendix may be found much involved in adhesions. It may be liberated by a longitudinal incision, through which its mucous-membrane tube may be shelled out and removed. Some difficulty may be experienced in finding and liberating an appendix which once has been acutely inflamed. Whatever is done, all of its mucous membrane should be removed. The wall of the appendix is less important. Usually the line of cleavage can be found, and the whole appendix extirpated.

Appendectomy by the lumbar route is practised when operation is done for exposure of the right kidney. If removal of the appendix is required, it is performed by opening the peritoneum *external to the mesocolon*. The caput coli is within easy reach, and, with the vermiform appendix, may be drawn into the wound and the operation completed. This incision may be used when for any reason the anterior operation cannot be done.

The postoperative complications following appendicitis are those found also after other abdominal infections and operations. For the treatment of *ileus*, see Vol. II, pages 552 and 595. *Pain* should require no treatment other than that addressed to its cause. In rare cases it may be due to compression of a nerve in the abdominal wall or other not serious cause and may be relieved with morphin. *Nausea* and *vomiting* should receive

the treatment described for ileus. *Phlebitis* of the femoral and portal veins are discussed under their respective heads. *Fistula* or *sinus* usually closes spontaneously, but when it persists beyond the time required for the ordinary healing of the wound, it should receive special treatment, and if it does not make progress toward healing it should be cured by operation (see Vol. I, page 304). *Ventral hernia* not uncommonly follows in drained abdominal wounds, and is a strong reason for early operation.

The operation for the cure of ventral hernia should be done as soon as it is clear that a hernia is developing. In the operation an overlapping of fascia and muscle should be secured (see page 42). In *unhealed wounds* with protrusion of viscera three courses are open: the protrusion may be kept controlled with a compressing dressing and a firm binder until the skin has covered it, and then an operation for ventral hernia may be done; or the granulating edges may be freshened and sutured, as described for the secondary suturing of wounds; or, if the defect is too great to be amenable to these measures, a filigree of silver wire may be inserted.

Appendicitis in children is prone to go on to suppuration, and is best treated by early operation. Operation should be expeditious and simple. The least possible handling of the intestine should be the rule. Early diagnosis, and early removal of the appendix are the essential steps.

If the appendix is not removed in the first stage of the disease, the subsequent treatment should be similar to that in adults. The difference is that children are more easily depressed by shock, and do not as readily throw out barriers of protecting adhesions as adults. When suppuration with spreading peritonitis has developed, with general abdominal tenderness, distention, bilateral rigidity, rapid pulse, with a comparatively low leukocyte count and a high percentage of polymorphonuclear leukocytes, operation must be as rapid and simple as possible. The abdomen should be opened, the appendix simply ligated and cut off, drains inserted, and the abdomen closed. While this is being done the suction tube should be removing pus; but coils of bowel should not be handled. If drainage is provided, the removal of the pus at the time of operation is not essential. After the operation the methods described under the rest treatment (Ochsner) should be employed: quiet, semi-upright position, nutrient enemata, proctoclysis and gastric lavage for nausea; no water or food by mouth and no purgatives.

If no primary operation is done, the rest treatment of Ochsner should be followed. As soon as an abscess is localized and evidently walled off, it should be evacuated. This may require from two to seven days, or longer.

Appendicitis in the female must often be treated as a complication of adnexal disease. When primary it requires no different treatment from that in the male. When secondary to tubal infection it should be exposed by the median incision which best exposes the tubes. The infected appendix should be removed.

Appendicitis in pregnancy should be operated upon early while the disease is still confined to the appendix. At this stage the appendix can be removed. When abscess has formed, it should be incised and drained, but no attempt to dig out an adherent appendix should be made. The disease runs a more rapid and dangerous course, and should be checked by early operation. The earlier in the pregnancy the operation is done, the less is the danger. A mild attack does not threaten the pregnancy, but a severe attack is very apt to cause abortion. Every effort should be made to prevent this.

It may be laid down as a rule that a pregnant woman with an acute attack of appendicitis should be operated upon as soon as possible during the first eighteen hours of the attack, and that a woman who has had one

attack of appendicitis, should be operated upon when she finds herself pregnant—all provided the operation can be done by a skillful surgeon.

Removal of the healthy appendix, when encountered in the process of another operation, is not usually justified. If there have been recurring attacks of appendicitis, and the patient desires its removal, it may be removed. The same may be said of cases of *dread of appendicitis*, not amenable to mental treatment, or of the cases of persons about to travel: in these, operation specificially for removal of the appendix is justified if reasonably demanded by the patient. But it may be said that where appendicitis occurs, usually there are surgeons capable of dealing with it.

Postoperative Treatment.—Most cases of appendicitis after operation require no special treatment. The chief danger to be feared is that of peritonitis. To be on the safe side for a few days all cases should be treated as though the danger were imminent. The patient should be placed in the inclined trunk position, and should be denied nourishment by mouth if any peritoneal infection was found at the operation.

Cases free from peritonitis and not requiring drainage, in which an ideal closure of the abdominal wall has been made, may be allowed to sit up on the tenth day and permitted to rest at home during all of the third week. During the third week they may walk about (see Postoperative Treatment of Abdominal Cases, Vol. II, page 529).

Cases requiring drainage should be treated for peritonitis. Tubular drains should be aspirated or cleaned by a gauze swab. Gauze and wicking should be removed usually on the second day and renewed. After that it is best changed every day (see Peritonitis, Vol. II, page 546).

Results of Operations for Appendicitis.—After its removal there are no symptoms referable to the absence of this organ. The appendix has no appreciable function. There is an abatement of the symptoms due to its inflammation. If adhesions form as the result of peritonitis or drainage, it is surprising how soon they usually disappear and leave the peritoneum smooth and shiny as before. In the majority of cases the absence of the appendix and the presence of an abdominal scar are all that reveal that an inflammation had existed and an operation was done.

Operations done in the first stage of the disease, before infection has extended beyond the appendix, should be without mortality. Surgeons of large experience, report groups of 100 or 1000 consecutive cases without a death. The same may be said of the removal of the appendix during the quiescent or interval stage after an attack has subsided, there should be no mortality.

In the cases of operation in the second stage, with local peritoneal infection and abscess, the mortality is very variable, depending much upon the skill applied in the operation. In inexperienced hands the mortality is high; in experienced hands it is considerable.

Appendicitis with spreading peritonitis is still more serious. The mortality among these cases is high, although here again experienced surgeons are able to keep down their death rate to an extraordinary degree.

The total mortality following operation in all cases varies largely with the proportion of early and intermediary cases and with the skill and experience of the operator. Some surgeons have 100 consecutive cases, representing all stages, without a death. In groups of several hundred consecutive cases, of all types as they come to the surgeon, the mortality among experienced operators ranges from 2 to 7 per cent.

The surgeon need not be concerned one way or the other for his statistics. Most of the patients that die after operation should not be classified as opera-

tive mortality; they die despite operation. Had they been operated upon earlier they should have recovered. The surgeon should be concerned only to do the best thing that can be done for each patient—the thing that offers the best hope of recovery and the statistics may be left to take care of themselves.

ACTINOMYCOSIS OF THE APPENDIX

This disease when infecting the abdomen shows a predilection for the vermiform appendix. When the disease is discovered while yet localized to the appendix or the appendix and cecum, the affected parts should be excised. Usually the infection, when discovered, has spread beyond the possibility of excision, and under these circumstances it is best treated with sulphate of copper or iodid of potassium. A hopeful prognosis may be given (see Actinomycosis, vol. I, page 272).

TUMORS OF THE APPENDIX

Tumors when *benign* should be removed along with the appendix because of the danger of their causing appendicitis. *Malignant tumors* should be removed with the appendix and as much of the adjacent bowel and other tissues as is necessary to insure against recurrence.

FOREIGN BODIES IN THE APPENDIX

Usually these bodies are found at the operation for appendicitis and are removed along with the appendix. When discovered at other operations it is wise to remove the appendix with its foreign contents because of the danger of appendicitis.

APPENDICULAR COLIC

Colic, caused by the effort of the vermiform appendix to expel its contents, fluid or solid, is best relieved by laxatives, enemas, and placing the patient in the position in which he finds the most comfort. While such a colic should be distinguished from appendicitis, the surgeon should always be ready to remove the appendix because the condition which provokes the colic may continue and engraft inflammation upon it.

The colic of appendicitis is due to the pressure of the products of inflammation upon the nerves and is cured by removal of the appendix.

HERNIA OF THE APPENDIX

Appendicitis existing in a hernial sac should be treated by removal of the appendix. If drainage is not required, a radical operation for the cure of the hernia may be done. If drainage is necessary, the radical cure of the hernia should be deferred until infection has subsided (see Hernia, page 17).

LIVER AND GALL-BLADDER

Anatomy.—The *liver* is situated in the right hypochondriac and epigastric regions. Its upper, dome-like surface conforms to the under surface of the diaphragm. Its five supporting ligaments are composed of folds of peritoneum except the round ligament which is the relic of the umbilical vein lying in the posterior edge of the falciform ligament. The lower border of the liver lies just behind the right costal margin and in a thin person can be felt at its lower part. The left lobe can be felt between the median line and the left costal arch. Being evolved along with the stomach, upper duodenum, and pancreas, from the primitive foregut, it receives its blood supply from the hepatic artery which is a branch of the celiac axis.

The hepatic artery passes to the liver in the gastrohepatic ligament above and internal to the common bile duct. The portal vein lies between and posterior to the two. The vessels coursing in the liver are held open by close adherence to the liver substance, and when

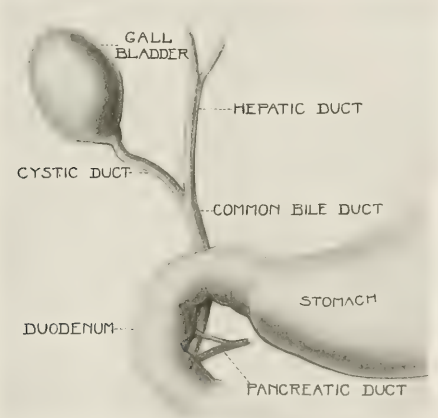


FIG. 1524.—ANATOMIC RELATIONS OF LIVER AND GALL-BLADDER.
Accessory pancreatic duct is shown.

divided do not collapse as do vessels surrounded by loose areolar tissue. Bleeding from wounds of the liver is profuse and continuous. The blood-pressure is low; and bleeding is easily checked by pressure.

The *gall-bladder* is a pear-shaped bag lying in a fossa beneath the under surface of the liver. Its fundus touches the anterior abdominal wall at about the tip of the ninth rib. This point is at the meeting of the costal arch and the outer border of the right rectus muscle. It is 8 or 10 cm. (3 or 4 inches) long, and has a capacity of about 45 c.c. (1½ ounces) (Fig. 1524).

The *cystic duct* from the gall-bladder is about 4 cm. (1½ inches) long, and runs downward and to the left to unite with the common hepatic duct to form the common bile duct. It lies between the layers of the lesser omentum. The *common hepatic duct* is formed by the junction of the left and right hepatic ducts. It is about 5 cm. (2 inches) long, and lies anterior and to the right of the portal vein.

The *common bile duct* is about 7.5 cm. (3 inches) long, and passes downward and slightly to the right to end at the biliary papilla in the posterior wall of the second portion of the duodenum. This opening is about 7.5 cm. (3 inches) from the pylorus. The duct is divided into three portions. (1) The supraduodenal portion lies in the free edge of the gastrohepatic omentum, and ends at the pancreas. Internal to it are the portal vein and hepatic artery the vein lying slightly posteriorly. These three structures lie along the anterior boundary of the foramen of Winslow. (2) The retroduodenal or pancreatic portion usually passes through the substance of the head of the pancreas; in some cases it lies in a groove in the posterior surface. (3) The third portion lies in the posterior and inner aspect of the wall of the second portion of the duodenum.

The common duct terminates in close relation with the terminus of the pancreatic duct (duct of Wirsung). Usually the two ducts join to form a common ampulla (diverticulum of Vater) which opens at the apex of a papilla of mucous membrane.

The average diameter of the cystic duct is 3 mm. (⅛ inch). The common hepatic duct averages 4 mm. (⅙ inch) in diameter, and increases in size from above downward. The common bile duct decreases in size from above downward, at its upper portion being about equal to the combined diameters of the cystic and hepatic ducts, and at its lower portion being scarcely larger than the cystic duct.

Access to the cystic, common hepatic, and the upper two portions of the common bile duct may be secured by passing a finger into the foramen of Winslow, making forward traction, and bringing in reach the part to be incised. The lower portion of the common duct may be reached by an incision through the peritoneum just to the right of the descending portion of the duodenum (see Vol. II, p. 739). This permits mobilization of the duodenum, and exposure of its posterior surface. When adhesions or exudate make this difficult, the anterior wall of the descending duodenum may be incised longitudinally and the duct approached from within the bowel. If it becomes necessary to incise the duct within the bowel the incision need not be sutured. The opening through the bowel wall should be closed by two layers of sutures.

THE LIVER

Contusion of the liver can often not be distinguished from rupture before operation, as the outward signs may be the same, because there are actually multiple minute lacerations of the liver substance. A patient who has received a blow upon the liver region, who has local pain or pain radiating toward the right shoulder, especially with *slow pulse* (bradycardia) from absorption of exhuded bile, should be treated for contusion or rupture. There is no sharp differentiation between the two, as the symptoms of contusion are the symptoms of laceration.

The patient should be kept quiet; and if the symptoms are progressive, and if the pain extends to the abdomen and shows peritoneal irritation, a small exploratory opening in the upper abdomen should be made under local anesthesia. If no bleeding is going on the wound should be closed; if bleeding is taking place the treatment for laceration should be applied. This treatment is important because the slowing effect on the pulse of the absorption of extravasated bile may more than compensate for the pulse rate-increasing effect of hemorrhage, and notwithstanding an abdomen full of blood, the pulse may still be slow.

Rupture of the liver is so serious an accident and the danger of fatal hemorrhage and peritonitis are so great that all cases are best treated by abdominal section. Operation should be done as early as possible as these cases are apt to be rapidly fatal (see Contusions, above). Free blood being found in the abdomen, a systematic search should be made for the wound. The hemorrhage is apt to be aggravated by opening the abdomen, for which reason no time should be lost in checking the bleeding. Packing a wound of the liver with gauze should be done with gentleness. The liver is extremely friable, and it is easy to increase the rent by forceful packing. But slight pressure is required to check the bleeding. After removing the blood from the wound it should be closed by sutures.

The best *suture of the liver* is accomplished by means of good-sized catgut in a large, blunt, curved needle. The needle should be round, without a cutting edge. Judgment is required in tying the sutures at the right tension. If too much tension is applied the thread will cut through the liver substance. Sutures should be applied a good distance from the edges of the wound (Fig. 1525). There have been used many forms of mattress suture but the simple running suture is as effective as any. It is well to combine it with a deep mattress suture.

In cases in which a fissure separates an end or edge of the liver from the rest of the organ the raw surface may be stitched over and over. If a raw surface is large, it is best to coagulate the blood in the opened vessels by means of the actual cautery or by hot water. Ragged tissue should be trimmed away. Gauze packing may often be combined with suture (Fig. 1526).

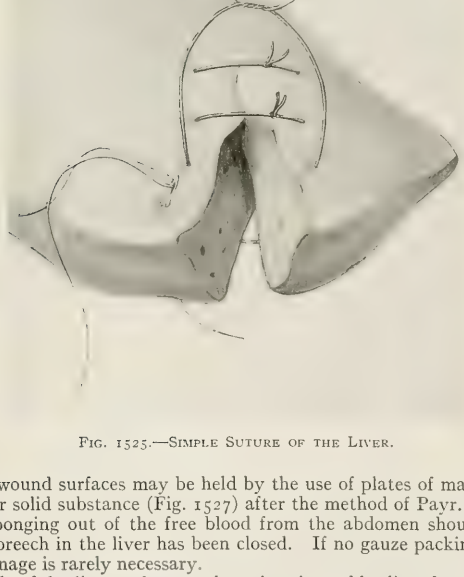


FIG. 1525.—SIMPLE SUTURE OF THE LIVER.

Large wound surfaces may be held by the use of plates of magnesium or some other solid substance (Fig. 1527) after the method of Payr.

The sponging out of the free blood from the abdomen should be done after the breech in the liver has been closed. If no gauze packing has been used, drainage is rarely necessary.

Wounds of the liver so long as they give rise to bleeding should be sewed or packed. A strip of omentum may be drawn into a wound to act as a tampon. Lacerated and incised wounds are best treated by suture as described above. Bleeding *bullet wounds* and *punctured wounds* when small may be treated by packing with a narrow strip of gauze. This may be brought out through the abdominal wall for drainage. In introducing gauze into a bullet wound, pains should be taken to determine the course of

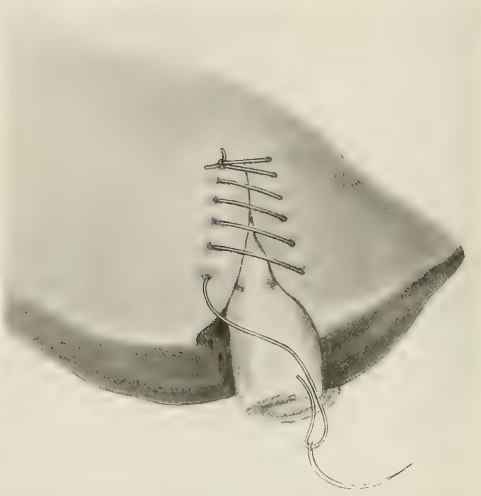


FIG. 1526.—SUTURE OF WOUND OF LIVER COMBINED WITH GAUZE PACKING TO CONTROL BLEEDING.

FIG. 1527.—SUTURE OF LIVER WITH THE AID OF MAGNESIUM PLATES.

the wounds so that gauze shall not be forced outside of the bullet track. To facilitate this operation a small drainage tube, split longitudinally, may be inserted to the depths of the wound, and with this as a guide gauze may be packed in. A wound of exit should be looked for.

In the case of large wound surfaces, with bleeding vessels, the individual larger vessels may be tied by passing a ligature around them on a curved needle.

The important requisite for the saving of life in wounds of the liver is not so much the method or nature of the suture as it is the timeliness of operation. Operation within the first hours will save life; delayed operation with any kind of suture will see life sacrificed.

Operations on the liver should spare as much blood as possible. At least one-third of the liver may be removed without injury to the general health. Animals survive removal of three-fourths or seven-eighths of the liver. The liver has great regenerative power.

Hemostasis in operations on the liver is the important matter. Many methods of blood control have been used: multiple sutures; mattress sutures; mass ligatures; actual cautery; hot water; ligation of individual vessels; tampon; tampon and suture; tampon, cautery and suture; suturing with omentum included to prevent cutting through of the sutures; compression clamps; suturing the liver to the abdominal wall; and sutures with compression plates. Suturing would control bleeding were it not for the fact that the needle opens more vessels and the sutures cut through the liver substance. The needle should be blunt-pointed. An ordinary silver probe is better than a sharp needle. It should be remembered that closing the abdomen increases the pressure, and promotes hemostasis.

J. R. McDill, of Milwaukee, proceeded as follows by clamping the pedicle of the organ to prevent bleeding in operations for excision of portions of the liver. The abdomen is opened on the right side just below the costal margin in the axillary line. If this is not the desirable location for the wound of operation, only a 2.5 cm. (1 inch) opening need be made for the forceps. An enterostomy clamp with rubber-covered arms is passed into the abdomen. One arm is inserted into the foramen of Winslow behind the vessels and ducts and the other in front far enough to grasp the hepatic artery. The compression should be very gentle and as near the duodenum as possible. With this control of the blood supply bloodless resection may be carried out. The compression may be continued for several minutes. The clamp should be left on as short a time as possible, and blueness of the intestine should prompt its immediate removal.

To secure better mobilization of the liver it may sometimes be necessary to divide the falciform ligament or the right lateral ligament. In some instances to expose the liver it may be advisable to divide the ribs and lift up a flap of thoracic wall.

McDill proposed that, after resection, if the tension on the sutures seem great, a gum-rubber bandage be passed around the liver.

Infections of the Liver.—Abscess of the liver, whether amebic, multiple, localized, or pyemic, should be evacuated as soon as a diagnosis can be made.

The *prophylaxis* of these diseases is important. In the tropics, care of the general health and the avoidance of uncooked vegetables which may come from regions polluted by infected water are important. The ameba is transmitted from intestine to food, much as typhoid is, and can be avoided by the same care. The prompt treatment of amebic dysentery is important, as practically all cases of amebic abscess have a history of preceding colitis.

The other forms of infection of the liver are to be prevented by checking the entrance of bacteria into the blood-stream. Abscesses in any part of the body should be drained. Infections about the anus, such as ulcers and infected hemorrhoids should be cured, because of their proneness to infect the portal blood-stream. The danger of abscess of the liver is one of the pressing reasons for early operation in appendicitis, for suppuration in connection with the appendix is a prolific cause of this disease.

The use of bacterins is especially indicated in multiple abscesses or those of metastatic origin. It is possible that this treatment may prove of much service, but up to the present time operation offers the only hope of recovery, nearly all cases perishing unless adequate drainage of the abscess is secured.

Operation for liver abscess should be undertaken early as the dangers of rupture into the thorax and exhaustion from sepsis are great. If the diagnosis is made by aspiration, all of the preliminaries for operation should have been made so that incision may follow the needle as a guide. It has often happened that pus has been found by aspiration, and operative incisions failed to discover the abscess.

With a satisfactory surgical environment it is best to perform an *exploratory operation* before a positive diagnosis has been made. An incision just below the right costal border exposes the liver to inspection and palpation. The hand, introduced through this opening, systematically explores the whole surface of the liver, searching for localized swelling, adhesions and the "resistant tense bogginess" described by T. L. Rhoads ("Diagnosis and Treatment of Liver Abscess," Medical Dept., U. S. Army). Tropical abscess is usually found in the front upper part of the right lobe. This represents a zone corresponding to the seventh, eighth, and ninth intercostal spaces. Punctures for exploratory purposes with a long aspirating needle can be made with greater safety and accuracy within the abdomen than through the walls of the trunk. If pus is discovered, its evacuation should be accomplished by the most direct route. Usually this will be through the thoracic wall. Anterior drainage lacks the advantage of gravity; and abscesses with an anterior opening have often required a second operation to secure better drainage. Cases are on record in which as many as forty-eight punctures have been made with a needle before the abscess was found.

The exceptional cases, in which the amebic infection has produced a necrosis and softening of liver substance without fluid pus capable of aspiration, must be discovered and drained with the aid of other signs and methods than aspiration.

Drainage *by the abdominal route* is indicated in abscesses located anteriorly or near the antero-inferior border of the liver; also when adhesions to the anterior abdominal wall serve to exclude the drainage tract from the peritoneum. If the peritoneum is exposed, it should be walled off by gauze packing, the abscess opened and its contents aspirated or sponged out. Necrotic material should be removed. Irrigation is highly undesirable. A large drainage tube surrounded by gauze packing should be inserted into the abscess.

Drainage *by the thoracic route* is applicable to the largest number of cases. When an abscess is identified by abdominal exploration and is situated where a more posterior opening will give better drainage, the abdominal wound may be closed, and attack through the chest wall instituted. If there is no urgency, while the abdomen is still open, the peritoneum about the abscess region on the liver and parietes may be irritated by rubbing it with sponges or a curette, with the view of causing adhesions. After two days the operation through the site of adhesions may be done.

In approaching the liver through the chest wall it is best to operate below the pleural sac if possible. The lower margin of the pleura is reflected onto the diaphragm along the line extending from the lower end of the sternum outward behind the seventh costal cartilage. On the right side, the lower border of the costal pleura corresponds with the level of the eighth rib in the nipple line; with the ninth rib in the midaxillary line; and with the twelfth rib in the posterior scapular line. The lower border of the lung corresponds with a line two ribs higher than that of the costal pleura. It is possible to resect 5 or 8 cm. (2 or 3 inches) of two or three ribs, and expose the costal pleura; and then with care dissect it upward so that a fairly high exposure of the diaphragm may be secured without opening the pleural sac (see Operations on the Diaphragm, Vol. II, page 553). This is the most satisfactory operation. The most usually effective approach is by resection of the eighth and ninth ribs at the midaxillary line or posterior to it. If necessary the seventh rib also may be resected (Fig. 1528).

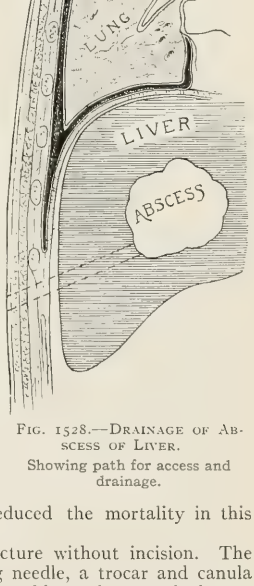


FIG. 1528.—DRAINAGE OF ABSCESS OF LIVER.
Showing path for access and drainage.

If a transpleural approach must be made, it should either be done in two stages in order to secure adhesions between the two pleural surfaces, or the two pleuræ should be sewed together before opening the abscess. Should the abscess already have perforated into the pleural cavity, a free resection of ribs should be done (see Empyema, Vol. II, page 402), the opening through the diaphragm made adequate, and the pleura and liver abscess drained with rubber tubes.

In approaching an abscess of the liver it is best to incise the liver capsule, and then proceed to the abscess with a blunt-ended instrument. If a knife is used to incise the liver tissue much blood is lost; a large drainage tube should be used.

A copious dressing should be applied over the wound to absorb the discharge. The tube had better not be disturbed for five days. By that time it may be removed and cleaned. Irrigation may then be instituted. Early and skillful operation has greatly reduced the mortality in this disease.

P. Manson treated liver abscess by puncture without incision. The abscess having been located by an aspirating needle, a trocar and canula is plunged into it. The trocar is removed, a rubber tube stretched on a rod is passed through the canula, and the latter removed. This leaves a rubber tube in the abscess. The well-equipped surgeon will prefer the open operation.

It is the practice in some tropical countries to find the amebic abscess with an aspirating needle, then pass in a large trocar, and leave in a rubber tube. The cavity is irrigated with salt solution and then filled with a 2 per cent. solution of bihydrochlorid of quinin. If this does not cure the disease the abscess is washed out and filled with iodin solution—4 Gm. (1 dram) tincture of iodin to 500 c.c. (1 pint) of salt solution. This treatment is accompanied

by the internal administration of powdered ipecac, 2 Gm. (30 grains) twice daily.

Actinomycosis of the liver is treated by constitutional measures, and by incision when an abscess is present (see Actinomycosis, Vol. I, page 272).

Syphilis of the liver, as an infection, is not amenable to local treatment (see Syphilis, Vol. I, page 283).

Tuberculosis may give rise to multiple or single caseous abscesses which may be evacuated by incision. Particularly in the case of a single abscess, if a diagnosis can be made, the cavity should be emptied, the inside treated with tincture of iodin, then injected with iodoform emulsion, and the wound closed without drainage. If a mixed infection exists, drainage should be used (see Tuberculosis, Vol. I, page 276).

Cirrhosis of the liver is not amenable to surgical treatment. The *ascites of cirrhosis* can be relieved by operation and sometimes cured. The palliative operation consists in *tapping*.

Paracentesis of the abdomen is performed when the amount of fluid has become so great as to cause discomfort and interference with function. For the more radical relief of the ascites of cirrhosis, an operation to cause adhesions of the omentum, liver and spleen with the anterior abdominal wall is done (see Ascites, Vol. II, page 557).

Tumors of the Liver.—*Benign tumors*, such as *angioma*, are removed by excision. *Malignant tumors* may occasionally be operated upon when discovered early. This may be said particularly of primary carcinoma of the gall-bladder which has extended to the adjacent liver. An early excision of the bladder and wide resection of the affected liver may remove the disease. It is scarcely worth while to attempt removal of a metastatic deposit in the liver even though the primary disease has been eradicated.

Resection of the liver is not difficult or notably dangerous. If the tumor involves a narrow portion of the organ, is somewhat pedunculated, or has a superficial attachment, it may be removed while an assistant's two hands make compression about it. By making a wedge-shaped wound, it can be closed by sutures. Large-sized catgut in a smooth curved needle is the best suture material. The pressure necessary to prevent bleeding need not be great. The sutures should be placed a good distance from the edge of the wound to prevent cutting out.

If a large mass of liver must be removed, bleeding may be prevented by heavy through-and-through sutures, the liver mass which is to remain and in the line of incision. Some surgeons have used the cautery for cutting the liver. Crushing clamps have also been of service. Dudley Tait injected hot water into the liver along the line of incision and by producing coagulation in the vessels was able to incise through a non-bleeding area.

Hot applications to the cut surface may be depended upon to stop the bleeding. Any raw surface which can not be closed should be sutured over to insure against bleeding and covered, if possible, with peritoneum from the omentum or elsewhere. Gauze packing may be employed when necessary to stop bleeding (see Wounds of the Liver, page 106).

Operations for hydatid cyst may be either by incision and drainage or by enucleation of the cyst. The first operation exposes the liver at the most prominent part of the cyst. The surrounding peritoneum and raw surfaces should be well protected by flat sponges. The danger of echinococcus infection of the wound should be kept in mind. This protection of the tissues should be carried down to the cyst wall. All of the parts being covered, a trocar and canula should be inserted through the wall of the cyst and the bulk of its contents removed without soiling the wound. The wall should

then be held up by toothed forceps and incised. The rest of its contents should be sponged out, and daughter cysts removed. The interior of the cyst should then be treated with antiseptic to destroy any remaining parasites. The edges of the cyst are swabbed with tincture of iodin and sutured to the skin, and the interior of the cavity drained with a mass of gauze enveloped in rubber tissue. The sac shrinks, becomes lined with granulations, degenerates into a sinus, and heals.

Enucleation of the sac should be carried out with the same care to protect the surrounding tissues against infection. The contents are drawn off, and the interior cleaned of fluid and daughter cysts. The inside of the cyst should be treated with iodin or phenol and dried out. The cyst may then be stripped out of its bed, and removed entirely. If the cavity is not too large it may be obliterated by sewing its walls together, and the rest of the wound closed. If some of the cyst is left behind drainage should be used.

These cysts may usually be exposed by anterior operation through the abdomen. If necessary some rib resection may be done. In some cases a lateral operation through the chest wall, as described for abscess, will be best. The results of operation in these cases are good (see Operations for Abscess of the Liver, above).

Hepatoptosis (prolapse of the liver) is usually associated with relaxation of the supports of all of the abdominal viscera, and operative treatment is not indicated. In cases in which the liver alone is in a state of ptosis, it may be held in place by shortening the suspensory ligaments, provoking adhesions between the dome of the liver and the diaphragm, suturing the anterior border to the abdominal wall with heavy sutures, and keeping the patient in the lowered thorax position until fixation has been secured.

Malformations of the liver, giving rise to projecting accessory lobes, need no treatment so long as there is no discomfort or interference with function. Such projections may be removed by the methods described for the treatment of wounds (page 106) and tumors (page 112) of the liver. In a case of downward elongation of the right lobe in the form of a tongue, I relieved the symptoms, which had long simulated appendicitis, by suturing the accessory lobe up near the costal border.

Intrahepatic cholelithiasis, the formation of stones in the hepatic ducts and their branches, should not be overlooked by the surgeon, or be mistaken for acute cholecystitis, perforating duodenal ulcer, or stone of the common duct. The enlarged segment of the part of the liver in which the obstruction has existed should attract the surgeon's attention as soon as it is exposed. Search should be made over the surface of the liver for a bulging area showing bile obstruction and irritation. If the stones are close to the surface this area may be incised, the stones removed. Drainage should always be used. If perforation of the surface of the liver has taken place it should be treated as an abscess. A stone or collection of stones near the surface of the liver having been recognized, it is a wise policy to isolate the region with gauze packing, and a few days later when adhesions have developed, the encysted stones may be removed by incision without fear of infecting the peritoneum. A biliary fistula is apt to persist for a long time after these operations.

Cystic dilatation of the common bile duct is best treated by exposure of the cyst, aspiration of its contents, resection of as much of the cyst wall as is necessary to reduce the cyst to a tube, and suture of the gap so as to reconstruct the duct. Before proceeding with the suture, the surgeon should examine the opening leading into the duodenum to be sure of its patency. The possibility of cystic dilatation extending for some distance into the wall

of the bowel with absolute closure of the bowel opening should not be overlooked, nor mistaken for bowel lumen.

THE GALL-BLADDER AND BILE-DUCTS

Wounds of the Gall-bladder.—Wounds of the gall-bladder should be closed by suture as soon after their occurrence as possible, for bile escaping into the peritoneal cavity is very apt to cause fatal peritonitis. The surgeon should not wait for the appearance of jaundice, either general or localized about the umbilicus, but should open the abdomen, if there is a probability of rupture of gall-bladder or bile-ducts. Free bile in the peritoneal cavity should be sponged out, inflicting upon the peritoneum as little traumatism as possible. Suture of the gall-bladder should be done with two layers of fine catgut.

In cases first seen after the lapse of several days, a walled-off abscess should be emptied and drained, but much care should be taken not to break down adhesions. No suture need be applied.

Wounds of the bile-ducts, if accessible, may be closed with suture. As these wounds are usually the result of bullet or stab, other injuries are apt to demand suture more urgently than the bile-duct. Usually it will be best not to consume the time necessary for the suture of a perforated duct, but to carry down to the perforation a rubber drainage tube, fix it securely, and surround it with a drain of gauze or wick. After a few days, when the drained tract has become walled off by adhesions the cotton drain may be removed. The tube should be left for at least a week, until a firm barrier of adhesions has developed. It may then gradually be shortened. It is removed entirely by about the end of the second week. The bile fistula may be expected to close by contraction of its lumen in the course of another two weeks.

Perforation of the gall-bladder or ducts by ulceration incident to the presence of a stone is usually preceded by inflammatory exudate which prevents invasion of the general peritoneal cavity. The abscess which forms should be exposed after careful protection of the peritoneum, its contents sponged out, and the cavity drained, as above. Care should be taken not to break up protective adhesions. Such a perforation may continue, and open into another viscus, such as the duodenum, resulting in spontaneous discharge of a stone and cure of an abscess. In these cases operation should be withheld unless it becomes evident that an abscess persists.

Infections of the Bile-Tract.—*Acute cholangitis,* not associated with gal - stone, is best treated by the method which Ochsner recommends for peritonitis; keeping the stomach empty by lavage and the withholding of gastric alimentation; the administration of water and food by rectum; and rest in bed. This treatment need not be continued longer than a week.

Acute cholecystitis with gangrene of more or less of the gall-bladder wall, sometimes with perforation, and sooner or later with peritonitis, is best treated by cystectomy, regarding the gall-bladder in much the same light as a gangrenous vermiform appendix. Drainage should be carried down to the stump of the amputated cystic duct.

Subacute cholecystitis, due to one or more of a variety of organisms, should be treated by cystotomy when the infection gives rise to septic absorption, when there is an accompanying cholangitis, when there is obstruction of the cystic or common duct, or when the gall-bladder is much distended. This means that drainage of the bladder is indicated when there is present an infection of its interior which is not subsiding.

Chronic cholecystitis, with or without cholangeitis, is best treated by cholecystotomy and the establishment of drainage.

Typhoid infection of the gall-bladder, in its chronic form, is the condition found in the so-called "typhoid carriers," and is remedied by cholecystotomy and drainage or by cholecystectomy. The latter is probably the more effective operation. It is possible that typhoid bacillus vaccination may take the place of surgery in this condition.

General Principles of Treatment of Infections of the Gall-Tract.—When an infection of the gall-bladder or bile ducts is not subsiding, and is of such a character as to be capable of causing toxemia or obstruction, and is capable of spreading to the ducts of the pancreas, drainage of the gall-bladder is indicated. Such an infection in the gall-bladder alone is cured by drainage, but when the infection is in the hepatic ducts or the common duct, without involvement of the bladder, cystotomy and drainage are of great value. The operation provides drainage and relieves pressure. In duct infections the drainage should be continued for a long time—at least until the escaping bile is found to be sterile.

If there is *occlusion of the cystic duct* cystotomy is of no avail for cholangitis until the patency of the duct is secured. If the infection is such as requires better drainage than is secured by the natural route, the gall-bladder should be removed and an effort to restore the occluded cystic duct should be made; this failing, the common duct should be incised and drained.

One of the important objects of cystotomy and drainage in duct infections is to prevent extension of the infection to the pancreas. And this is just what the operation can do. Cholecystitis and cholangitis cause pancreatitis; pancreatitis aggravates cholecystitis and cholangitis; drainage of the ducts through the gall-bladder destroys the vicious circle. If the operation were applied earlier, before the symptoms begin to cry aloud for relief, there would be fewer cases of pancreatitis. Drainage must be continued until sterile bile escapes. If operation succeeds in removing all obstruction a cure may be expected.

The *removal of the gall-bladder* is called for in: (1) acute gangrenous cholecystitis; (2) cases in which the mucous membrane has been destroyed; (3) cases in which the gall-bladder has lost its elasticity and is thick and sclerotic; (4) cases in which the cystic duct is permanently occluded; and (5) cancer of the gall-bladder.

The *surgical treatment of typhoid bacillus carriers* by cholecystectomy has resulted in the elimination of the organisms and should be a recognized procedure when bacterins and other internal measures fail. In the chronic inflammatory conditions of the gall-bladder, cholecystectomy is by no means the ideal operation. If there is a thoroughly patent cystic duct, and the gall-bladder has some contractile power, cystectomy is not a desirable operation. Disease of the mucous membrane of the gall-bladder may be cured by cholecystostomy. Its chief indications are irremedial occlusion of the cystic duct and cancer. Fine judgment is required in determining whether or no a gall-bladder, because of fibrosis of its walls or pericystic adhesions, has lost the power to empty itself. If it has, it should be removed.

In *acute biliary colic*, there is a disposition to operate at once, and give the patient relief. Ochsner has shown that the colic is excited by the passage of contents of the stomach into the duodenum. If the stomach is washed out so that food, mucus, and fluid are removed, the colic ceases, and the patient is given relief better than is secured by morphin. All food and drink by mouth should be discontinued; rectal alimentation should be instituted

in their stead; the patient should be kept at rest; and then at the convenience of patient and surgeon a deliberate operation may be carried out.

Gall-stones need not be the object of attack. The absence or presence of stones is not the important thing. Treatment should be aimed to relieve *infection* and *obstruction*. These are the important surgical conditions. Aside from their relation to these two conditions, stones are of little moment, and too much is said about them in surgical therapy. When operations are done for infection or obstruction in the gall-tract, and stones are discovered, they should all be removed. They are commonly found in the gall-bladder, and easily removed. The operation when uncomplicated should be practically without hazard.

When operation is undertaken it is not completed until every stone is removed. To leave a stone is to invite recurrence of symptoms. This is particularly true of stones in the ducts. A systematic palpation of the ducts should be made to this end. Usually the stones must be removed unbroken. In some cases, soft stones in the gall-bladder or ducts may be crushed by the fingers and moved on without incising the organ containing them. In some cases it is possible to press onward an unbroken stone until it enters the duodenum.

Gall-stones impacted at the exit of the bladder should be manipulated back into the gall-bladder and removed.

Stones in the cystic duct are usually not impacted, and can be manipulated back into the gall-bladder for removal. Unless such stones are removed the growth of bacteria around them is quite apt to produce serious spreading infection. Often the gall-bladder will already have undergone the inflammatory infiltration which indicates removal. Cystectomy is by no means the operation of choice. Cystostomy in these cases presents the advantage that constant drainage can be secured, and as infection may have reached the hepatic ducts or the pancreatic duct, drainage through the gall-bladder is a most important provision. Cystectomy in cystic duct gall-stone cases, therefore, should be reserved for the cases without infection, in which operation is done for obstruction—and these will be found to be very few. Of course, the causes for cystectomy above enumerated, apply here also.

Stones in the common duct should be removed by incision of the duct (choledochotomy). Drainage through the abdominal wound should be provided. Rarely a stone can be manipulated on into the bowel or back into the bladder.

Stones in the hepatic ducts should be treated as though in the common duct. They should be manipulated down into the common duct and removed by choledochotomy; or they may rarely be pressed into the bowel or gall-bladder.

Complications of gall-tract disease are due usually to *infection* and *obstruction*. *Perforation of the gall-bladder* should be treated by immediate exposure of the lesion. Acute perforation usually means gangrene of the bladder, indicating cystectomy and drainage. Chronic perforation usually means ulceration, and localized abscess, which is apt to be associated with so much disease of the bladder wall as to make cystectomy desirable.

When *perforation between the bile-tract and the gastro-intestinal tract* has occurred, no treatment is necessary if the stones have passed and drainage is free. But adhesions, giving rise to partial obstruction and defective drainage, and retained stones, causing obstruction and fostering infection, require to be relieved. When operations for these latter conditions are done the fistulous openings in the stomach or intestine should be exposed and closed, and the

opening in the bile-tract drained after obstruction to the free passage of bile into the bowel has been eliminated.

The prolonged irritation of stone may cause a *stricture of the ducts*. In the *cystic duct* this is not uncommon, and if treated by cholecystostomy a mucous fistula will result. Cholecystectomy is the operation of choice. *Stricture of the common* duct, a much rarer occurrence, is to be treated by plastic operation, division of the duct and reimplantation into the duodenum, or by cholecystenterostomy (see page 125).

Biliary fistula is one of the sequelæ of operation upon the bile tract which often requires treatment. Usually these fistulæ heal at the right time, that is when obstruction and infection have been overcome. There is a nice natural balance which usually may be left to operate automatically after obstruction has been removed and an external escape for the bile has been provided. If the fistula does not heal, the surgeon should address himself to the cure of the obstruction rather than to measures to compel the stoppage of the external discharge.

Fistula persisting after cholecystotomy is usually due to failure to remove, all of the stones and is cured by their removal. If the discharge is due to inflammatory enlargement of the head of the pancreas, free bile drainage is the best treatment.

The allowable treatment which may be applied to the fistula is by the suction cup. Copious irrigation of the gall-bladder with salt solution is of service in some cases. Forcible injection in the presence of infection may drive the infection up into the hepatic radicals, and is dangerous.

How long should a biliary fistula be allowed to discharge? This is a question which must depend much upon the condition of the patient. If bile is not entering the intestine enough to color the stools, and the stoppage is beginning to affect the health of the patient, another operation to overcome the obstruction must be done.

A fistula which persists because the gall-bladder has been sewed to the skin, is cured by cutting it free as far as the peritoneum.

(See Stricture of the Common Duct, page 131; Fistula, vol. I, page 304.)

Feeding the patient with bile collected from the fistula is of decided value in persistent obstruction of the common duct (Schmilinsky: Zentralbl. für Chir., page 1667, 1912). Patients can not take by mouth enough bile to be of any value; it soon becomes nauseating and repulsive in any vehicle. But by passing a tight-fitting catheter into the fistula and wearing a receptacle, the bile may be collected from the fistula, and twice daily it may be introduced with a stomach tube at the time the stomach is emptying itself after gastric digestion is completed. Patients who have become emaciated and depressed from the loss of bile may thus be brought up to a good state of health for safe operation for the obstruction.

Saline injections through a biliary fistula may be employed to advantag when more bodily fluids are required. Nearly every operation for infection of the bile tract is followed by fistula, and through this the patient can be given warm saline, much as in proctoclysis. L. L. McArthur (Jour. Am. Med. Assoc., vol. liv, No. 1, January 1, 1910) advised a flow of not more than 6 drops a minute and a pressure of not more than 50 cm. (20 inches) elevation. He recommended flushing the duodenum in this way with an alkaline salt solution for the treatment of biliary vomiting. This method may also be employed to cleanse the bile tract of mucus and inflammatory detritus.

Appendicitis as a complication of gall-bladder infection should always be borne in mind. When the surgeon is operating for cholecystitis he should

examine the appendix. It often happens that the cholecystitis has subsided and the only abdominal lesion present is an appendicitis which is perhaps, secondary to it. These two lesions are often found together, their symptoms are often confused, and operation should take them both into account.

Cancer of the Gall-bladder.—This disease may be cured by removal of the gall-bladder if the disease has not extended beyond its walls. Cases which are recognized before operation cannot be expected to be cured. The hopeful cases are those which have not advanced far enough to give symptoms adequate for their identification. Invasion of the liver by extension, if not too wide, may be treated by resection of the adjacent liver. *Cancer of the common duct*, if operable, is to be treated by resection and cholecystenterostomy.

OPERATIONS ON THE BILE-TRACT

Operation for infections of the bile-tract, especially if complicated by the presence of gall-stones, should be done early in order to forestall extension of infection into the adjacent ducts. Another reason for early operation is that the continuation of bile-tract infections gives rise to adhesions in the duodenohepatic region, which in themselves may ultimately require operation. The most commonly indicated procedure in early cases is incision and drainage of the gall-bladder (cholecystostomy), the danger of which is very slight and the curative power of which is very great.

The position of the patient is important. The ordinary table capable of elevation and depression at either end is desirable. In order to throw forward the posterior abdominal wall so as to bring the bile tract more prominently into the wound a sand-bag should be placed behind the back opposite the gall-bladder. Such a sand-bag should be fairly firm, 50 cm. (20 inches) long and 38 cm. (15 inches) in circumference. A special elevator, attached to the operating table, is also used for this purpose.

The appliances for operation include but few special instruments. Long retractors, to expose the deep ducts, are necessary. A small aspirating trocar for removing the contents of the gall-bladder is useful. For removing stones from the gall-bladder a scoop is used. Two sizes are desirable. In lieu of the special scoop the spoon curet and bladder scoop may be employed. For removing stones from deep situations a small scoop, such as a sinus curet, is best. Long forceps for extracting stones are useful. The layout should include also fine probes, fine curved needles, and needle forceps for deep suturing.

For draining the gall-bladder, rubber tubing 1.3 cm. (½ inch) in diameter is used. The tube is best held in the cystostomy opening by a purse-string suture, tightly tied to seal the opening. For draining peritoneal areas outside of the gall-bladder, the cigarette drain is employed. Drainage of the opened common duct is accomplished by a rubber-tube having a rounded notch cut at one end. This notch should set astride of the duct at its opening, to which it should be made fast by a suture on either side.

The preparation of the patient should be the same as for other abdominal operations (Vol. II, page 499). The operative environment and the prevention of shock have been discussed (Vol. I, page 176). If jaundice is present, it is customary to give 5.2 Gm. (80 grains) of chlorid of calcium daily in divided doses for two days preceding the operation. This is believed, but not proved, to increase the coagulability of the blood which is reduced by jaundice. When there are decided evidences of lowered coagulability

of the blood or when purpuric spots are present, operation should not be done unless the urgency for operative relief is very great.

Obstructive jaundice, caused by stones in the common duct, should not be operated upon in the presence of acute disturbances indicating local congestion and infection. It is best to wait until bile appears in the stools or until the acute symptoms of infection have subsided.

The anesthetic of choice is ether by the open-drop method. Many surgeons regard the general anesthetics as unsafe, and give just enough nitrous oxid to produce a twilight anesthesia to protect the patient from the psychic depression of fear. Infiltration of the sensitive tissues with 1 : 400 novocain solution is used in the lines of incision; and to produce postoperative comfort the area outside of the zone of operation in the abdominal wall is infiltrated with 1 : 600 solution of quinin and urea hydrochlorid. These last drugs must not come into contact with the skin or the wound itself. They are for deep injection.

Subcostal Operations for Exposure of the Gall-bladder and Bile-Ducts.— The simple abdominal incision, through the outer third of the right rectus

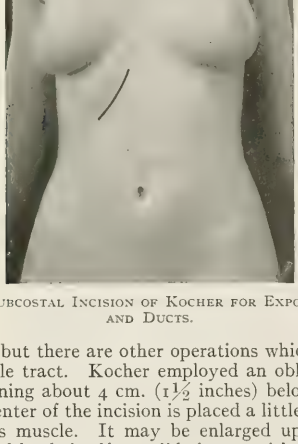


FIG. 1529.—OBLIQUE SUBCOSTAL INCISION OF KOCHER FOR EXPOSURE OF GALL-BLADDER AND DUCTS.

muscle is adequate; but there are other operations which have been devised especially for the bile tract. Kocher employed an oblique incision 10 cm. (4 inches) long, running about 4 cm. (1½ inches) below the costal margin (Fig. 1529). The center of the incision is placed a little outside of the outer border of the rectus muscle. It may be enlarged upward or downward, gives good access and lends itself to solid closure without danger of hernia. It is closed as described under Abdominal Operations.

For the best exposure, a sand-bag should be placed behind the patient's back at the level of the liver. This throws the lower surface of the liver forward and causes the intestines to gravitate downward. In addition to this it is of advantage to elevate the head of the table so that the head is about 13 cm. (5 inches) higher than the foot. When a vertical incision is used, this position has the disadvantage that the abdominal wall is tight, and retraction is difficult. When an oblique incision is combined with a vertical incision, the best possible exposure is secured.

The combined vertical and oblique incision was recommended by Mayo Robson. This begins as a vertical incision 10 or 13 cm. (4 or 5 inches) long, from the right costal arch downward through the outer part of the rectus

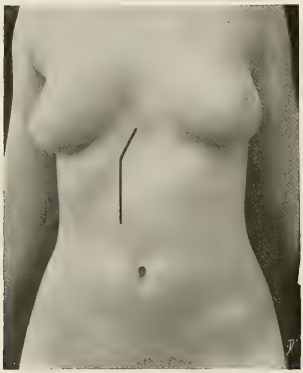


FIG. 1530.—INCISION OF ROBSON FOR EXPOSURE OF GALL-BLADDER AND DUCTS

muscle. If this does not give sufficient room, the incision is continued upward and inward along the costal margin as far as necessary (Fig. 1530).

A. D. Bevan (Annals of Surgery, vol. xxx. page 17) made an incision at the outer border of the rectus and added two oblique arms to it—one at either

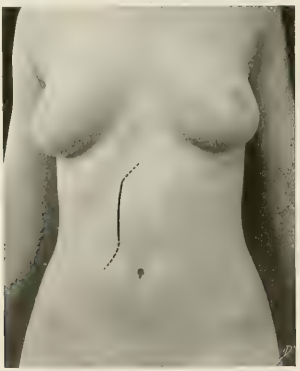


FIG. 1531.—INCISION OF BEVAN FOR EXPOSURE OF GALL-BLADDER AND DUCTS. The upper oblique incision should be just below the free border of the ribs.

end. He curved the upper one of the oblique incisions inward, and the lower arm downward and outward. These oblique incisions need not always be added. They may be so placed as to divide only the fascia and not the muscle (Fig. 1531).

For exposure of the gall-bladder region, an incision may be too large, and permit unnecessary escape of intestines. If there is much fat in the abdominal wall, the superficial incision should be considerably larger than the muscular incision.

Other incisions for exposing the gall-bladder and bile tract have been described (Vol. II, pages 505 and 507). The most useful incision is the vertical one, made through the outer part of the sheath of the right rectus muscle. When the deep ducts are to be attacked, the incision is made through the junction of the middle and outer thirds of the rectus, 8 or 10 cm. (3 or 4 inches) long, having its upper end near the costal border. From the upper end of this another incision may be carried upward and inward through

FIG. 1532.—METHOD OF EXPOSING GALL-BLADDER AND DUCTS BY DRAWING LIVER OUT OF THE ABDOMEN.

A layer of gauze prevents slipping.

the anterior and posterior sheaths of the rectus muscle as far as the median line if more room is needed. This same division of the aponeurosis in front of and behind the rectus may be made outward and downward at the lower end of the vertical incision in case a more external exposure is desired. By dividing the aponeuroses alone the muscle is spared.

For simple exposure of the gall-bladder a longitudinal splitting of the right rectus muscle and a transverse division of the transversalis fascia and peritoneum, as is done in the lower abdomen, is to be recommended.

After opening the abdomen, the appendix, the right kidney, the head of the pancreas, and the stomach should be palpated or inspected to eliminate disease in these organs which might have been responsible for the symptoms.

For *exposure of the deep ducts* Robson has shown that better results may be

secured by pulling down the liver and bringing out of the abdominal wound the inner half of the right lobe. This is accomplished by traction on the gall-bladder and margin of the liver by grasping with a gauze pad. By adequate retraction through a free incision, the liver is displaced forward by this method to such a degree that the common duct is brought into access to a surprising degree (Fig. 1532).

Cholecystotomy (incision of the gall-bladder) is used for exploration of the interior of the gall-bladder, drainage or removal of its contents. When the opening is not closed but left for permanent drainage it is called **cholecystostomy.** The gall-bladder is exposed by one of the incisions described above. If adhesions are present they are separated by blunt dissection, or divided, and if necessary tied (see Adhesions of the Duodenal Region, Vol. II, page 557). The abdomen having been opened and the organs examined, the gall-bladder is isolated from the rest of the peritoneum by gauze pads. If the gall-bladder is much distended it should be grasped with two mouse-tooth clamps and part of the contents should be drawn off by an aspirator, inserted between them. This fluid should be regarded as infected. The fundus is then incised and the forceps caused to grasp the two lips of the wound. The opening should be about 2.5 cm. (1 inch) long—large enough to perform whatever operation is indicated. Bile is sucked out with a syringe or removed with sponges. Stones are lifted out with the scoop. After the last stone apparently has been removed, the surgeon should palpate the ducts to determine if any stones remain. Stones in the cystic duct may be pressed back into the gall-bladder, and removed by that route.

If stones have been found it is usually best to drain the gall-bladder. Drainage is not indicated in cases which are free from infection of the bile tract, pancreatic disease, obstruction, and abnormal discharges. These cases are exceptional; and the surgeon is always on the safe side in terminating the operation as a cystostomy.

If no cause for drainage has been found, as when an exploratory operation has been done and the gall tract found free from disease, the opening in the bladder should be sutured and the abdomen closed. The bladder wound is best closed by a continuous, fine, chromic catgut, through-and-through suture of all of the coats, which should be covered in by a second catgut suture involving only the seromuscular coats. This is such a suture as is employed in closing wounds of the intestine. If there is fear of infection or obstruction in the common duct, causing pressure upon the wound, the latter should be anchored at either end to the wound in the abdominal wall, so that in the event of leakage or the necessity for opening the bladder it shall be easily accessible for drainage.

Cholecystostomy (an opening for drainage in the gall-bladder) may be done in one or two stages. The beginning of the operation is the same as cystotomy. A distended gall-bladder should be aspirated before opening it.

The *operation in one stage* is continued as for cystotomy. The gall-bladder is grasped by two pairs of forceps and opened between them. Stones are removed, the gall-bladder dried out, and the ducts palpated. The surgeon having done what is necessary, a tube is fixed in the gall-bladder and the abdomen closed. The tube should be of smooth rubber about 1 cm. (⅓ inch) in diameter, and should have 5 or 7.5 cm. (2 or 3 inches) of its length within the gall-bladder. It is fixed by a catgut suture which catches the wall of the tube and passes around the wound as a purse-string suture embracing all of the coats but the mucosa (Fig. 1533). If the wound is large for such a suture an over-and-over seromuscular suture may close

the wound down upon the tube and then be continued around it. This is tied, and a second purse-string suture applied outside the first and tied around the tube as the first is depressed into the gall-bladder (see Purse-string Sutures, Vol. I, page 201). If the wound is small, but one purse-string need be used. These are tied sufficiently tightly to prevent leakage from the gall-bladder. The peritoneum and posterior sheath of the rectus muscle are then sutured, being embraced in the same continuous suture.

This peritoneal suture should catch the gall-bladder close to the tube on either side of the latter (Fig. 1534). It is not advisable to sew the gall-bladder to the skin or anterior aponeurosis, as the fistula which remains is often difficult to heal. The tube is allowed to emerge through the abdominal wall at the place where it most easily presents. The rest of the abdominal wound is closed about the tube by layer sutures.

FIG. 1533.—FIRST PURSE-STRING SUTURE IN GALL-BLADDER.
The suture passes through the wall of the tube so that the suture may be cut from the inside of the tube with a narrow knife, when early removal of the tube is desired.

Some surgeons permit the tube to discharge its bile into the dressings. This entails frequent changes of dressing. A more satisfactory arrangement is to conduct the tube into a 300-c.c. (10-ounce) bottle which can be made fast to the binder outside of the dressing. The tube should be arranged so that it shall not kink or become compressed or obstructed. The bottle should not drag upon it. A good plan is to allow the end of the tube to drop into the neck of the bottle surrounded by a plug of gauze (Fig. 1535).

The *operation in two stages* is done to eliminate the possibility of infection of the peritoneum. The abdomen is opened, adhesions are separated, the gall-bladder and bile ducts are examined; and then, if it is determined that the bladder should be opened, it is sutured to the peritoneum in the abdominal wound in such a way that an elliptic surface is exposed. A packing

of gauze is carried down to this, and the rest of the abdominal wound closed, leaving room for exit of the gauze. After two or three days, when adhesions between the gall-bladder and peritoneum of the wound have formed, the gauze is withdrawn and the gall-bladder incised. The further exploration of the interior of the bladder cannot be accomplished with as much facility

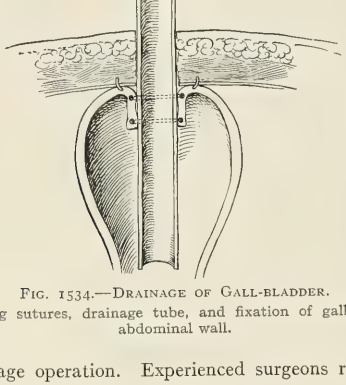


FIG. 1534.—DRAINAGE OF GALL-BLADDER.
Showing purse-string sutures, drainage tube, and fixation of gall-bladder to anterior abdominal wall.

as in the one-stage operation. Experienced surgeons rarely employ this method.

If drainage of the gall-bladder is the sole object of the operation, it is not necessary to sew it to the parietal peritoneum. This operation has the

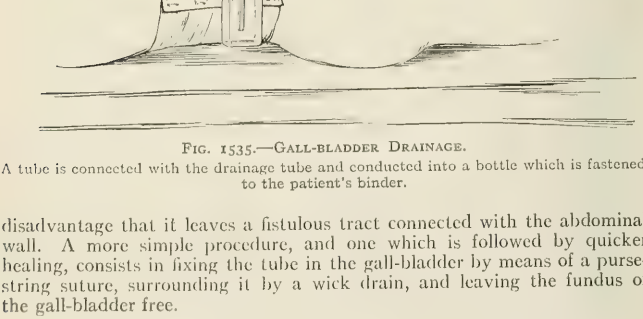


FIG. 1535.—GALL-BLADDER DRAINAGE.
A tube is connected with the drainage tube and conducted into a bottle which is fastened to the patient's binder.

disadvantage that it leaves a fistulous tract connected with the abdominal wall. A more simple procedure, and one which is followed by quicker healing, consists in fixing the tube in the gall-bladder by means of a purse-string suture, surrounding it by a wick drain, and leaving the fundus of the gall-bladder free.

Cholecystenterostomy (anastomosing the gall-bladder with the intestine) is done preferably with the duodenum, but if this is not accessible union may be made with the upper jejunum or colon. The operation is done for unremovable obstruction in the common duct. The operation is performed

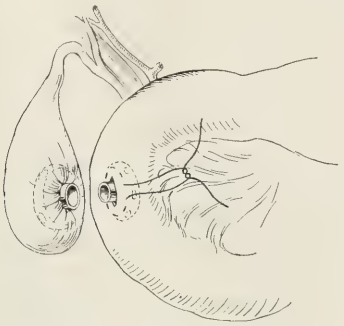


FIG. 1536.—CHOLECYSTDUODENOSTOMY.

Operation with anastomosis button. The button has been placed in the gall bladder and held by purse-string suture. The purse-string is about to be tied in the intestine.

precisely as intestinal anastomosis (*q.v.*). It may be done with the anastomosis button (Fig. 1536 and 1537) or by simple suturing. In skillful hands the latter method is to be preferred. The opening should be 1.2 to 2 cm. (½ or ¾ inch) long. When the jejunum must be used, intestinal exclusion (*q.v.*) is advised, in order to prevent intestinal contents entering the gall-bladder.

FIG. 1537.—CHOLECYSTDUODENOSTOMY WITH BUTTON.

Operation completed.

Moynihan practised end-to-side intestinal exclusion and simple lateral anastomosis of the gall-bladder to the bowel (Fig. 1538). Operations done beyond the duodenum may be followed by volvulus unless the bowel is properly anchored.

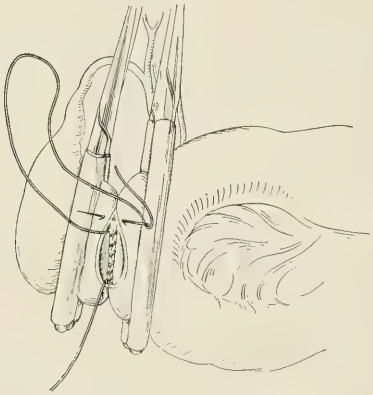


FIG. 1538.—CHOLECYSTJEJUNOSTOMY.
Showing method of anastomosis between gall-bladder and jejunum.

FIG. 1539.—CHOLECYSTECTOMY.
Showing peritoneum incised in front of cystic duct and retracted, ligatures around duct in two places and duct divided between them. The cystic artery is tied and divided. The liver is held with the aid of a gauze sponge.

Cholecystectomy (removal of the gall-bladder) is begun the same as cholecystotomy. The dividing of adhesions necessary for isolation of the bladder is often a large part of the operation. The peritoneal aspect of the gall-bladder should be exposed well down upon the cystic duct. There is but one difficult part of the operation, that is ligation of the cystic duct and artery. It is often most convenient to do this part of the operation first although most surgeons work from the fundus backward toward the cystic duct.

The liver and gall-bladder are drawn downward and forward into the wound after the method already described (page 121), and the gall-bladder and main ducts separated from the rest of the peritoneal cavity by pads. The gall-bladder is drawn forward with the fingers or a broad clamp, and

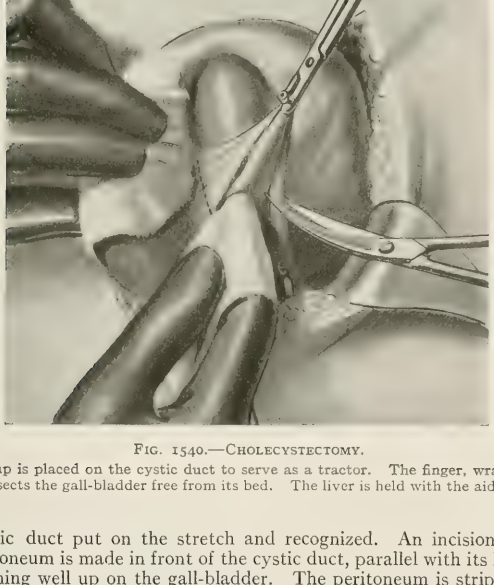


FIG. 1540.—CHOLECYSTECTOMY.

A clamp is placed on the cystic duct to serve as a tractor. The finger, wrapped with gauze, dissects the gall-bladder free from its bed. The liver is held with the aid of a gauze pad.

the cystic duct put on the stretch and recognized. An incision through the peritoneum is made in front of the cystic duct, parallel with its long axis, and running well up on the gall-bladder. The peritoneum is stripped back and the cystic duct isolated for its whole length. Two ligatures are then placed on the duct, the duct divided between them, and two ends cauterized to sterilize their mucous membrane (Fig. 1539).

The cystic artery and vein, lying above and to the inner side of the duct, are brought into view by drawing forward the stumps of the duct. The vessels are divided between two ligatures. The vessels may sometimes be included in the ligatures of the duct. The incision in the peritoneum is then carried upward in the form of a racket or an ellipse about the fundus

of the bladder and the latter dissected free from its bed by a finger passed about its walls (Fig. 1540). There should be but little bleeding. After the removal of the bladder, the margins of peritoneum are sutured, and, if no infection has escaped external to the bile vessels, the wound is closed without drainage (Fig. 1541). If there is a possibility that infection may be present or that any obstruction may occur in the common duct, a drainage tube should be fixed at the stump of the cystic duct. This is always a safe thing to do as a discharge of bile may take place even when not expected after many days when the ligature has softened.

If there is infection in the common duct, hepatic ducts, or pancreas, or temporary obstruction in the common duct, *drainage of the ducts* is urgently called for. In such cases the ligature or clamp is removed from the stump of the cystic duct before the peritoneum has been sutured, the duct is split

FIG. 1541.—SUTURE OF PERITONEUM AFTER REMOVAL OF GALL-BLADDER.

to widen its mouth and a drainage tube, double notched at the end (Fig. 1542) is passed into the duct, and held by a catgut suture catching the wall of the tube and the wall of the common duct. A split tube containing gauze or wick is placed to the outer side of the first tube, and both are brought out through the abdominal wound.

When there is some question as to whether drainage is necessary, the cystic duct may be ligated with plain catgut, and a drainage tube placed at its mouth. In the course of two or three days the catgut has softened, and if there is any mechanical need of drainage bile will flow from the tube, which in the meantime has become shut off by adhesions from the general peritoneal cavity.

When drainage is employed, the peritoneum is closed over the bed of the gall-bladder back as far as the place of emergence of the tubes from the cystic duct. (The indications for cholecystectomy are given on page 115.)

Incision of the hepatic duct (hepatocholangiotomy) for stone is required in those rare instances in which the stone cannot be propelled forward or crushed (hepaticolithotripsy). The duct is exposed by the same methods as the common duct. It is incised longitudinally and the obstruction removed. If no obvious infection is present the duct should be closed with two layers of sutures. Whether the duct is sutured or left open, a drainage tube should be carried down to the duct and fixed with one or two sutures so that its end can not become displaced away from the wound in the duct. Obstruction, not due to stone, causing dilatation of the duct, should be relieved. Strictures should be incised. When an impassable obstruction exists a new bile channel should be constructed around it.

Fig. 1542.—Drainage Tube for Application to Bile-duct.

Showing manner of notching end of tube.

Incision of the common duct (choledochotomy) is often required for the removal of impacted stone. Exposure is secured by the methods described above. Adhesions are separated and the gall-bladder followed down to the cystic duct. Thence the parts are retracted and the path to the common duct made free. Some adhesions may require to be cut and ligated. Instead of depending upon the posterior sand-bag alone to throw forward the deep structures, the gall-bladder and the edge of the liver should be grasped by the hand covered with gauze, and drawn down from behind the costal arch, and then lifted forward through the abdominal wound so that the under surface of the liver looks forward and the common duct is put on the stretch. In thin patients by this method the duct may be brought forward level with the skin surface.

Pads are applied to wall off the rest of the peritoneum and the ducts palpated. If the stone is movable it may be pressed back into the upper part of the duct which is the most accessible. The stone and the duct are grasped between two fingers and the duct incised longitudinally. The stone is picked out with forceps. The bile which flows forth from the wound should be regarded as infected, and sponged up as fast as it appears. Other stones may be brought down from the ducts above. The removal of one stone should not be the aim of the operation. The surgeon should satisfy himself by further examination with the fingers, probe and scoop, that there is not another stone below or above. The finger introduced into the duct may detect a stone lodged at the ampulla.

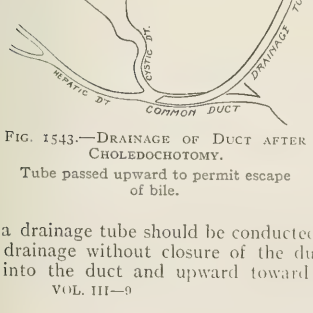


Fig. 1543.—Drainage of Duct after Choledochotomy.

Tube passed upward to permit escape of bile.

Closure of the duct by suture is by no means necessary. If the operation has been done expeditiously and there is no urgency the duct may be closed by a row of sutures. But in all cases a drainage tube should be conducted down to the site of the operation. If drainage without closure of the duct is practised a rubber tube is passed into the duct and upward toward the hepatic duct for about 2.5 cm.

(1 inch) (Fig. 1543). The opening in the duct should be closed down to the size of the tube and the latter caught by the suture to hold it in place. In addition to the tube for carrying off the bile, a second drain of wick or gauze enveloped in protective or a split tube should be carried down to the outer side of the duct.

Some surgeons prefer to apply a suture to the duct before incising it. The threads are then held aside, the duct opened, the stone extracted, and the sutures tied (Fig. 1544). If the duct is sutured and the gall-bladder drained a tube should still be carried down to the wound in the duct. Sutures of the duct should be applied the same as for the intestine. The simple transverse suture, embracing all the coats except the mucous membrane, is best.

The abdominal wound is closed about the tubes. If the duct is not sutured, a tube leading from the inside of the duct should be conducted into a

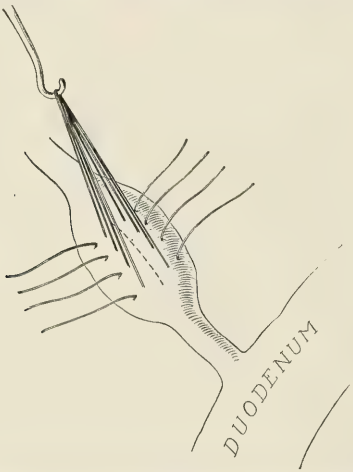


FIG. 1544.—SUTURES APPLIED FOR CLOSING DUCT BEFORE MAKING INCISION.
The sutures are held aside, the duct incised, the stone removed, and the sutures tied.

bottle as in cholecystostomy. The drainage should not be removed too early. A tube discharging bile should be removed when the bile becomes sterile and no symptoms of occlusion beyond it are present.

Rarely is it necessary to operate upon the second or *retroduodenal portion* of the common duct because a stone can usually be squeezed back into the first portion. When necessary the second portion may be exposed by an incision through the peritoneum external to the duodenum, and the duodenum moved inward, as in the operation described for displacement of the duodenum for gastroduodenostomy (Vol. II, page 739). As the duct lies in the substance of the pancreas the gland must usually be divided in order to expose it. After incision of the duct, and removal of the stone, drainage should be used.

A stone which is caught at the *ampulla* is best reached by *duodenocholedochotomy*. After locating the stone by palpation, a 2.5-cm. (1-inch) longitudinal incision is made in the anterior wall of the duodenum (see Enterotomy, Vol. II, page 567). The edges of the wound are held apart and the mucous membrane dried with sponges. The protuberance made by the stone always can be felt, and usually seen. Sometimes the stone is seen presenting at the orifice of the ampulla. The lower end of the duct is incised through the intestinal mucosa, and the stone lifted out with forceps or a scoop. In some cases it is possible to dilate the orifice sufficiently without incising it. If there is any difficulty in locating the stone, the fingers of the left hand passed down along the duct from above combined with those of the right hand in the bowel should engage the stone between them.

If the stone has been high above the ampulla, and an incision of the second portion of the duct has been required to remove it, the retroperitoneal space has been invaded. Fortunately, it is usually the case that chronic inflamma-

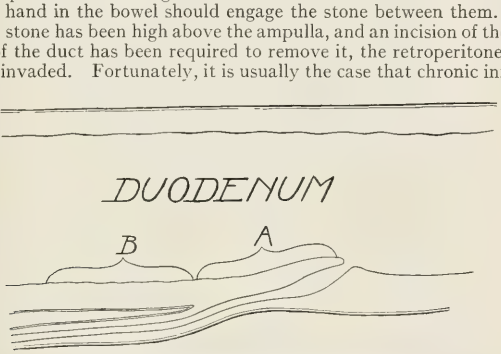


FIG. 1545.—TRANSDUODENAL CHOLEDOCHOTOMY.

The incision into the duct should be made preferably in that part of the duct which lies in the intestinal wall (*A*). Such an incision is uncomplicated. An incision through the posterior wall of the duodenum at *B* opens the retroduodenal portion of the duct and makes an opening into the pancreas or retroduodenal space.

tory adhesions bind the second portion of the duct to the duodenum. These prevent leakage into the retroperitoneal space, and it usually suffices to sew the wound of the duct to that of the bowel with silk sutures, thus completing a choledochoduodenostomy above the ampulla (Fig. 1545).

The closure of the anterior wall of the duodenum should be by two rows of sutures (see Enterorrhaphy, Vol. II, page 567). Intraduodenal incision of the third portion of the duct requires no suture of the wound. In some cases it will be found best in operating upon the third portion of the duodenum to make a vertical incision to its outer side and rotate it inward.

The treatment of **transverse division of the common duct** is by simple suture such as is used for blood-vessels. If there is need for drainage a T-tube may be used and the duct partly closed. The tube is constructed by placing in the duct a rubber tube which enters the duodenum. A second tube is fixed by two catgut sutures into the wound. This second tube emerges at the abdominal wound (Fig. 1546). When the sutures melt the tube in the duct passes into the duodenum and the other tube may be removed.

Operations for stricture of the common duct are usually required for the relief of the obstructions due to inflammatory deposits. Commonly such strictures are associated with stone, and when the latter is removed the ob-

struction still exists. After removing a stone from the duct, it is wise to pass a probe, followed by dilating forceps down through the duct into the duodenum. A well-dilated duct is the best assurance for the escape of hidden stones in the hepatic ducts.

When a stricture cannot be dilated, and when from the history the surgeon knows that he is dealing with an impermeable obstruction, operation is facilitated by the presence of enlargement of the ducts which is always found above the obstruction. As a rule, it may be stated that an *anastomosis* should be made between the duct above the obstruction and the duodenum or jejunum. This may be done with an anastomosis button or by simple suture, the general principles of the operation being the same as for entero-anastomosis (Vol. II, page 646).

Fig. 1546.—Suture and Drainage of Common Bile-duct after Transverse Division.

Removal of a segment of the duct (choledochectomy) and end-to-end union is successfully done after precisely the same technic as is employed in end-to-end suture of blood-vessels. The operation may be required for tumor, wound, gangrene, or extensive cicatricial degeneration. This operation is facilitated by closing the duct over a small rubber tube placed in its lumen and carried down into the duodenum, although this is not necessary. Or only the posterior part of the duct may be united, drainage established and the duct later allowed to close. A rubber tube may be held in the duct by a plain catgut suture. When the suture melts the tube passes into the bowel. The suture should be covered by plication of the peritoneum (Figs. 1547, 1548 and 1549).

When so much of the duct has been removed that the interval cannot be closed, and when the proximal stump is too short for implantation in the bowel, it should always be remembered that so long as the communication between the hepatic duct and gall-bladder is potent, *cholecystenterostomy* or *cholecystogastrostomy* can be performed.

FIG. 1547.—CHOLEDOCHECTOMY.
After removal of the gall-bladder and resection of the duct the two divided ends are united. The raw surface is sutured over. The posterior suture of the duct is applied.

FIG. 1548.—CHOLEDOCHECTOMY.
A rubber tube is placed in the duct and intestine.

FIG. 1549.—CHOLEDOCHECTOMY.
The suture of the duct is completed and the whole covered over by a fold of duodenal wall as recommended by W. J. Mayo.

Plastic operations for restoring part of the extirpated anterior wall of the duct may be carried out by turning over a flap cut from the anterior

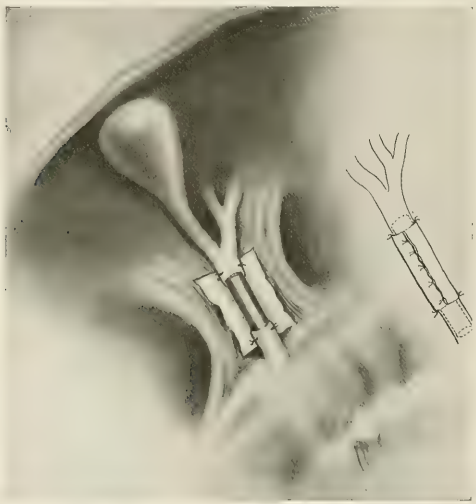


Fig. 1550.—Reconstruction of Common Bile-duct with Graft of Fascia Lata.

wall of the duodenum or the stomach, by implanting a segment of transplanted vein or artery, or by transplanting a segment of the vermiform appendix, or piece of fascia. A rubber tube should be placed between the

Fig. 1551.—Reconstruction of Common Bile-duct from Flap of Duodenal Wall. A flap is cut from the duodenum and turned back.

two stumps of duct and caught with sutures. The piece of fascia, cut from the rectus sheath or transversalis, should be wrapped around the duct and

tube. It should be sewed to the duct but not to the rubber tube (Fig. 1550). Autogenous grafts of tissue have given a fair degree of success.

Direct implantation of the stump of the common duct into the duodenum is highly desirable but can be done only in cases in which the loss of duct tissue has not been great. Anastomosing the duct with the jejunum has been done but is not to be recommended.

The operation of indirect implantation may be done by one of several methods. A. J. Walton (Surg., Gyn. and Obst., xxi, 1915) reconstructed a continuation of the duct from a duodenal flap. A flap is cut out of the duodenum and turned downward (Fig. 1551). A rubber tube is inserted into the stump of the duct, and caught by a suture of fourteen-day chromic cat-

FIG. 1552.—RECONSTRUCTION OF COMMON BILE-DUCT.

The opening in the duodenum is closed except for a space at the base of the flap large enough to admit the rubber tube connecting the common duct with the bowel.

gut. The opening in the duodenum is closed except for a hole at the base of the flap large enough to admit the rubber tube (Fig. 1552). The tube is inserted into the bowel, and the duodenum held up close to the tube and sutured. The duodenal flap is then sewed around the rubber tube (Fig. 1553). The abdomen should be closed with drainage. The rubber tube passes into the bowel in fourteen days.

A *reconstruction of the duct* may be done successfully after the method of Hans Kehr. A rubber tube is inserted into the proximal end of the duct, and fastened by two catgut sutures. The tube is then laid on the anterior surface of the duodenum, and the other end inserted into the bowel through a small opening made about opposite the ampulla. The end that is inserted into the bowel has attached to it a sponge about half the size of the lumen of the bowel. The sponge is wrapped with catgut to compress it. The tube is then covered in by suturing the wall of the duodenum over it, after the method of gastrostomy devised by Witzel. One of the lower sutures

should catch the wall of the tube to anchor it to the intestine. A surface of omentum is sewed over the suture line. The duodenal juices dissolve the catgut about the sponge; peristalsis acting upon the sponge draws out the tube as soon as the catgut holding it has dissolved; and a canal is left lined by peritoneum. The objection to this operation is that it narrows the lumen of the duodenum. This objection may be overcome by sewing omentum over the rubber tube which is placed on the duodenum, without plicating the bowel. This operation forms a canal having bowel on one side and omentum on the other.

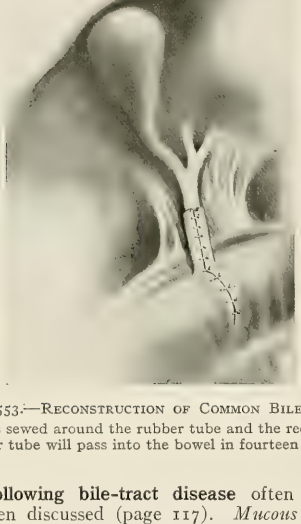


FIG. 1553.—RECONSTRUCTION OF COMMON BILE-DUCT.
The flap of duodenum is sewed around the rubber tube and the reconstruction completed. The rubber tube will pass into the bowel in fourteen days.

Complications following bile-tract disease often require treatment. *Bile fistula* has been discussed (page 117). *Mucous fistula* of the gall-bladder should be treated by the removal of the obstruction in the cystic duct, if a stone, and by cholecystectomy if due to stricture of the duct. *Hernia* should be avoided by careful suturing of the wound. *Peritoneal adhesions* are discussed elsewhere. *Neuroses* should not be treated by repeated operations, but by hygienic measures.

After operations on the bile tract *recurrences* are observed in a large proportion of cases. These recurrences of symptoms may be unavoidable, or due to faulty diagnosis or treatment, or to complicating disease. Calculi may reform. If the stump of the cystic duct is left long after cholecystectomy, stone may form in it. Peritoneal adhesions about the duodenal region may give rise to continuation of disturbance. Calculi may have been overlooked in the operation. The cholangitis, which was present before the operation, may persist. Chronic pancreatitis, cancer of the pancreas, stricture, or fistula may complicate the convalescence. The mis-

take of operating on the gall tract for symptoms due to syphilis of the spinal cord should not be made.

After-treatment of Bile-tract Cases.—The after-treatment of patients operated upon for bile-tract disease is not different from other abdominal cases (Vol. II, page 529). The drainage tube of cholecystostomy should be removed at the end of a week. The thin light yellow character of the bile indicates its sterility. If drainage is continued there is always danger of reinfection, as an indication of which the bile becomes dark green in color and contains many pus cells. Rarely is prolonged drainage advisable.

After cholecystectomy the drains should be removed at the end of a week. To minimize the production of adhesions, the drainage tract may be filled with sterilized petrolatum.

Following operations on the common duct, the tube which passes down to the duct may be removed on the fifth day, and the tube from the gall-bladder on the seventh day. If a catheter has been placed in the common duct, it should be left for two or three days after the other tubes have been removed.

The same general measures for improving the condition of the patient should be applied as are used after other abdominal operations. Nausea from the retention of fluids in the stomach should be treated by gastric lavage. If proctoclysis is indicated and the patient does not well tolerate the fluid in the rectum, saline solution may be given through the gall-bladder tube or the common duct tube. This should not be started until thirty-six hours after the operation when adhesions have become firm enough to protect the general peritoneum from leakage.

THE GENITO-URINARY ORGANS

THE KIDNEYS AND URETERS

Anatomy.—The *kidneys*, two in number, are situated in the posterior part of the lumbar region behind the peritoneum, one on either side of the spinal column. They extend from the eleventh ribs nearly to the crests of the ilia, the right being somewhat lower than the left. Each is about 10.3 cm. (4 inches) long, 5 cm. (2 inches) wide, and 2.5 cm. (1 inch) thick. The external border is convex, and looks outward and forward. The internal border is concave and has, from before backward, renal vein, artery, ureter (Fig. 1554). Above each kidney is the suprarenal body; behind are the crus of the diaphragm, quadratus lumborum, psoas, and twelfth rib. In front of the right kidney are the

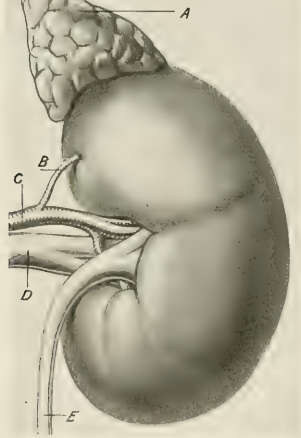


FIG. 1554.—RELATIONS OF THE STRUCTURES AT THE HILUM OF THE KIDNEY (REAR VIEW). *A*, Suprarenal capsule; *B*, accessory renal artery; *C*, renal artery; *D*, renal vein; *E*, ureter.

right lobe of the liver, second part of duodenum, and ascending colon; in front of the left kidney are the cardiac end of stomach, lower border of spleen, tail of pancreas, and descending colon. The upper end of each ureter is expanded to form the *pelvis of the kidney*. The blood-vessels are above and the ureter below (Fig. 1555).

The outer borders of the kidneys are 9 to 10.3 cm. ($3\frac{1}{2}$ to 4 inches) external to the lumbar spines. The upper pole of each kidney is about 5 cm. (2 inches) from the median line of the body. The inner border of the right kidney is close to the vena cava; the left kidney lies about 2.5 cm. (1 inch) from the aorta (Fig. 1556).

There is a layer of loose areolar tissue about each kidney, containing a great deal of fat. Two layers of fat are separated by the retrorenal fascia and the prerenal fascia. The iliohypogastric and the ilio-inguinal nerves pass obliquely downward and outward just below and posterior to the kidney (Fig. 1557).

The kidney is surrounded by a fibrous capsule which is easily stripped away. The hilum is on a level with the first lumbar vertebra. The vena cava lies to the right of the

aorta; the artery is longer and the vein is shorter on the right side. The short right renal vein should be borne in mind in removing the right kidney.

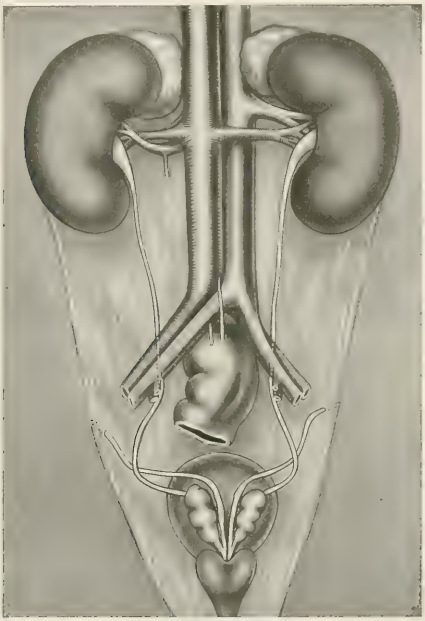


FIG. 1555.—URINARY ORGANS SEEN FROM BEHIND.

The renal artery before entering the hilum divides into two sets of branches; anterior and posterior, which have but slight anastomotic connections, thus dividing the kidney into two segments so far as the circulation is concerned (Fig. 1558).

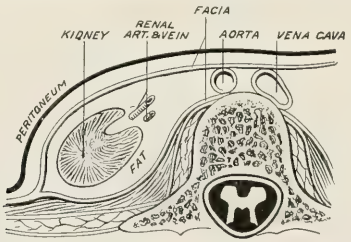


FIG. 1556.—HORIZONTAL SECTION THROUGH UPPER LUMBAR REGION.

The *accessory renal arteries* should always be borne in mind when operating at the hilum of the kidney. More than one artery may require to be tied. Ligation and division of an accessory artery may be all that is needed to relieve an obstruction causing hydronephrosis.

The kidneys lie in front of the two lower ribs. The lumbar vessels and nerves which pass outward from the spine must be considered in operative exposure of the kidney through the lumbar region (Fig. 1550).

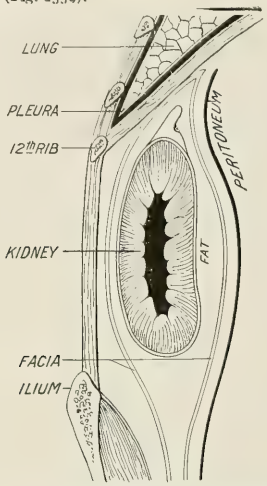


FIG. 1557.—VERTICAL SECTION THROUGH KIDNEY.
Showing perirenal fascia. The lung in this picture fills the pleural sac as is possible only in full inspiration.

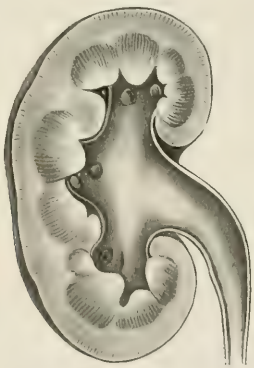


FIG. 1558.—KIDNEY SPLIT OPEN.
Showing pelvis, infundibula, pyramids, and calices.

The ureters carry urine from the kidneys to the bladder. Each kidney has a ureter. They are about 36 cm. (14 inches) long and 4 mm. ($\frac{3}{16}$ inch) in diameter. The normal distended lumen is about 3 mm. in diameter. They begin opposite the spine of the first

lumbar vertebra, and pass downward behind the peritoneum, converging to enter obliquely through the bladder wall and empty through orifices at its base. Behind each ureter is the psoas muscle, the common or external iliac artery, and the genitocrural nerve. In front are the spermatic vessels, the ileum (on the right side), and the sigmoid flexure (on the left side). The right ureter lies close to the outer side of the vena cava, and at the brim of the pelvis just behind the vermiform appendix. Internal to the left ureter is the aorta—being 2.5 cm. (1 inch) from it above and 1.3 cm. (½ inch) from it below. Under the bladder the ureter lies above the vas deferens which it crosses. In the female it is parallel with the cervix uteri and about 1 cm. (⅓ inch) away from it, crossing the upper third of the anterior vaginal wall to enter the bladder opposite the middle of the vagina. The ureters are closely adherent to the peritoneum.

Urinary Antisepsis.—Many substances when given internally have the power to contribute an antiseptic property to the urine, but no artificial antisepsis can take the place of free drainage and a healthy mucous membrane.

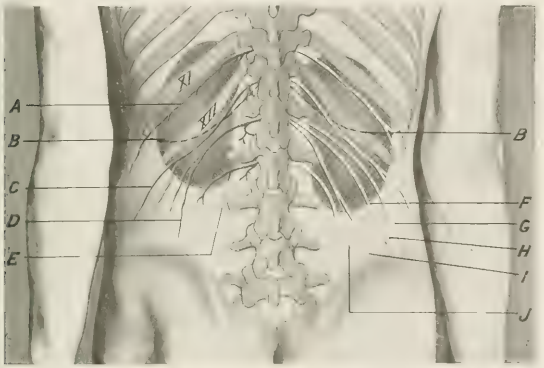


FIG. 1559.—SURGICAL RELATIONS OF STRUCTURES POSTERIOR TO KIDNEY.

A, Last intercostal artery; *B*, *B*, pleura; *C*, subcostal artery; *D*, first lumbar artery; *E*, second lumbar artery; *F*, ilio-inguinal branch first lumbar nerve; *G*, hypogastric branch first lumbar nerve; *H*, iliac branch first lumbar nerve; *I*, posterior branch first lumbar nerve; *J*, second lumbar nerve. (Diagrammatic.)

Most of the substances used internally for this purpose are scarcely antiseptic; but rather slightly inhibitory to bacterial growth.

The older drugs, such as cubebs, benzoic acid, tar, and balsam-of-copaiba, can scarcely be said to have an antiseptic property when used internally. To administer enough of these substances to secure an antiseptic action is to threaten the kidneys with serious irritation. The same may be said of salol. The search for an ideal urinary antiseptic has been unavailing. Boric acid, uva ursi, and sandalwood oil have some slight effect in cystitis due to staphylococci.

Hexamethylenamin is more potent than any of the above drugs. While not useful in all infections it has a wide range of special indications. It is given by mouth in doses of 0.5 to 1 Gm. (7½ to 15 grains) 2 or 3 times daily. It is decomposed and liberates formic aldehyd which is strongly antiseptic—and incidentally irritating. This end-product is so potent an antiseptic that a small dosage is effective. The action of the drug is hastened by administering it with acid sodium phosphate. It

should not be given with potassium citrate. Formic aldehyd exerts little or no antiseptic action upon alkaline urine. It, therefore, can not be expected to cure infection in alkaline cystitis. The more strongly acid the urine is, the more strongly it acts. It should not be given unless the urine is acid. High acidity is more effective than increasing the dosage of the drug. Its chief value is as a prophylactic. Administered in cases of normal urine it is capable of preventing infection. It is of especial value in urinary fistula. During convalescence after prostatectomy while there is incontinence it is most useful. It will also prevent cystitis in typhoid infection, and destroy the infectiousness of typhoid urine. Preceding any operation on the urinary tract, it is useful to prevent infection of normal urine.

The basic dyestuffs have decided inhibitory action on the growth of bacteria in the urinary tract. *Trypan red* and its allied substances seem to have selective action against tuberculous infections. *Methylene-blue* in doses of 0.12 to 0.25 Gm. (2 to 4 grains) in capsules, with powdered nutmeg or belladonna, is a weak germicide. It may be increased to 0.2 to 0.4 Gm. (3 to 6 grains) four times daily. It acts slowly. As an inhibitor of bacterial growth it acts promptly and effectively. In solution as weak as 1:150,000 it inhibits the growth of staphylococci. The colon bacillus is resistant to it except in stronger solutions. Staphylococci become resistant to it after a few days, and it should, therefore, be discontinued for a few days at alternate intervals. Hexamethylenamin may be given in the intervals.

Methylene blue is of especial value in infections of the bladder due to staphylococci. It has no considerable antiseptic or inhibitory value in urethral infections.

Antiseptics for local application are discussed under Asepsis and Antisepsis, Vol. I, page 27; and Surgical Materials, Vol. I, page 57. The general principles of treatment are found under Inflammations, Vol. I, page 228.

The acidity of the urine may be increased by the administration of acid sodium phosphate. Benzoic acid and benzoates have the same effect but to a lesser degree.

Local antiseptics which may be applied to the urinary tract are the same as for other regions. Milder solutions are required because of the sensitive nature of the epithelium. Boracic acid is most highly prized. The silver salts are employed when stronger action is needed.

The *Bulgarian bacillus* is useful in the treatment of *alkaline cystitis* and *pyelitis*. The bladder or pelvis should be washed out with sterile water. No antiseptic should be used. Two to four tablets of pure culture of Bulgarian lactic acid bacillus should be dissolved in 30 c.c. (1 ounce) of warm water. The mixture is well stirred and then injected into the bladder or pelvis. In alkaline fermentation, the bacteria produce an acid reaction, and a great improvement is promptly noted.

Tests of the Functional Activity of the Kidneys.—Operations upon the prostate and other important organs of the genito-urinary system should not be done unless the surgeon has positive knowledge of the functional activity of the kidneys. The most useful method is the *phenolsulphonephthalein test*. All prostatics should be subjected to such a test before operation.

Twenty or thirty minutes before the test is given, the patient takes 300 or 400 c.c. of water by mouth. The bladder is then emptied by means of a catheter. Then 1 c.c. (15 minims) of a prepared solution, containing 6 mg. of phenolsulphonephthalein to the 1 c.c., is given subcutaneously. (This solution is especially prepared for the purpose; see Keen's Surgery, Vol. VI, page 634.) The catheter is left in place and the urine is allowed to drain into a test-tube containing one drop of a 25 per cent. solution of sodium hydroxid. The exact time of the injection is noted, and the exact time of the first appearance of the faint pinkish coloration of urine from the bladder. If there is no mechanical obstruction, the catheter is removed at the first appearance of the dye in the urine. The patient is

instructed to void urine into a receptacle at the end of an hour, and into another receptacle at the end of the second hour. If there is prostatic or other obstruction the catheter is left in place, but the urine is collected separately in periods of one hour each. Each sample of urine, representing one hour's collection is measured and its specific gravity taken.

Enough 25 per cent. sodium hydroxid solution is then added to make the urine decidedly alkaline, as the purple color is only brought out in alkaline urine. The amount of water added to sample is made up to 1000 cubic centimeters accurately. From this a small amount is taken and compared with a standard sample. This standard sample consists of 3 mg. of phenolsulphonephthalein in 1 liter of water and rendered alkaline by the addition of one or two drops of 25 per cent. solution of sodium hydroxid. This purplish red fluid retains its color for an indefinite period. By comparing the diluted alkaline urinary solution with the standard solution by means of colorimeter the percentage of the drug eliminated is estimated. This is a method of great accuracy.

In normal individuals the coloring matter appears in the urine in from five to eleven minutes after the injection. From 40 to 60 per cent. of the drug is eliminated in the first hour, and 20 to 25 per cent. in the second hour. From 60 to 85 per cent. is eliminated in the two hours.

In nephritis or in cases of chronic urinary obstruction the functional activity of the kidneys is greatly reduced. The appearance of the dye may be delayed to fifteen or twenty minutes or more, and the total elimination in the first hour may be as low as from 5 to 40 per cent. Retarded elimination means danger of uremia.

Decrease of elimination contraindicates operation. If treatment by restricted diet, fluids, alkalies, rest, and elimination of sepsis do not improve elimination, chronic interstitial nephritis probably is present. Treatment will improve elimination if the disturbance is due to urinary obstruction, such as prostatic hypertrophy or pyelonephritis. Very much retarded elimination contraindicates operation, except in urgent emergency.

To test the function of only one kidney, the following method is used: The patient drinks 600 or 800 c.c. of water twenty minutes before the test. The ureters are then catheterized. The catheters should enter the ureters for a distance of 10 cm. (4 inches). The catheters should have openings in the end instead of the side alone. These are the catheters of Albarran, No. 6 or 7. A small urethral catheter is then passed into the bladder and the bladder washed out. The dye is injected in the arm or buttock, the time noted, and the time of the first appearance of color from the urine is noted. The urine is collected separately from each kidney for one hour from the time of the first appearance of the color. The quantity of urine passed, the specific gravity and the amount of urea are noted.

Another test of great delicacy, which can be found described in works on urology, is the indigocarmin test.

In normal persons the time of appearance and the rapidity of elimination is about the same in each kidney. If one kidney is diseased, the time of appearance and the rate of elimination are both retarded. The latter is the more important factor of the two. Experts are able to distinguish between pyelitis and pyelonephritis complicating stone. In tuberculosis the test gives an index of the presence of disease, and the amount of functionating kidney left. In no case does the test fail to detect unilateral disease.

In urinary obstruction with residual urine, if the condition is of long duration, retarded elimination will be found. To operate at once on these patients is very dangerous. If the pressure is taken from the kidneys by catheterization or drainage, and the patient given much water by mouth, the diet restricted to simple food, alkalies administered, and the patient put at rest in the fresh air, the functional integrity of the kidneys is restored and operation may be done without danger. Urinary antiseptics should be used to clear up infection before operation.

Cases in which the excretion is reduced to zero or nearly to zero, associated with high urea content in the blood, are most serious and even so slight an operation as passage of a sound or cystoscope may cause death.

The *intravenous phlorizin test* is another useful expedient for testing renal function Phlorizin is a glucosid which after being injected into the blood appears as glucose in the urine. The ureters or bladder are catheterized. The phlorizin solution is prepared by placing in the barrel of a glass syringe a tablet containing phlorizin, 0.01 Gm., and sodium chlorid, enough to make 0.03 Gm. This is then dissolved in 2 c.c. of hot distilled water and injected into a vein in the arm. The urine which flows from the catheter is tested at once for glucose. This is done by allowing the urine which comes from the catheter to drop into test-tubes of heated Fehling's solution until a positive reaction for sugar is observed. It will be found that in cases with normal renal permeability sugar appears in about seven minutes; in cases with damaged renal permeability sugar usually does not begin to appear until fifteen minutes have elapsed.

The *hypodermic phlorizin test* is less accurate than the intravenous. The same amount of the drug is used. The injection is made in the thigh. Sugar normally appears in the urine in from fifteen to twenty minutes; it may be delayed to thirty minutes.

The *indigo-carmin test* is preferred by some urologists. The *percentage urea test* gives an index of the relative functional power of each kidney to concentrate urine. The *blood-nitrogen-retention test* gives an index of the ability of the kidneys to excrete nitrogen products.

The simplest expedient is the *water test*. No fluids or food are given to the patient for two hours before the test. Then 500 c.c. of carbonated water is drunk. The bladder is then emptied by catheter and the catheter left in place. In normal cases about 20 c.c. of urine, with a specific gravity of 1022 will be collected during the first fifteen minutes. About thirty minutes after the ingestion of the carbonated water the kidneys begin to sustain the extra burden. During the third quarter of an hour the amount of urine excreted is about four times more than during the first quarter. The increased secretion continues for about an hour, and then gradually declines. As the amount of urine increases the specific gravity decreases to 1003 to 1006. If the permeability of the kidneys is damaged by nephritis, the excretion during the first quarter is usually below 20 c.c.; but during the third quarter, while the amount is increased, the specific gravity continues about the same.

Genital Tuberculosis.—Tuberculosis is discussed under each of the genital organs which may become infected. The constitutional treatment should be urged as the most important. As the kidney or bladder is involved in about half of the cases of genital tuberculosis by the time they come to the surgeon, operative removal of the disease cannot be looked upon as a routine measure. As evidences of healed tuberculosis are rarely found in the prostate and seminal vesicles, it must be assumed that unless the treatment of tuberculosis of these organs is radical a fatal termination of the disease must be expected. This is particularly important because of the danger of meningitis and miliary tuberculosis in these cases. Epididymectomy alone cannot be depended upon to eradicate the disease when found in the epididymis, as in a large proportion of cases the disease has extended beyond the testicle.

As the epididymis is the usual starting point in genital tuberculosis, and the kidney in the urinary organs, these two organs should receive the primary surgical attention. Fully one-half of cases of genital tuberculosis have tuberculosis in some other organ, usually the lungs, and should therefore have the attention of the surgeon addressed to other than the genital system. Within one year after operation, 50 per cent. of the cases may be expected to die, and within six years 85 per cent. succumb. A patient can not be said to be cured until ten years have elapsed.

Bad results may be expected in the cases in which the surgeon neglects the constitutional treatment. In the cases given intelligent immunization treatment much better results should be expected.

The operative treatment of genital tuberculosis should inflict the least possible shock. Every consideration should be given to preserving the patient's resistance.

H. H. Young (Surg., Gyn. and Obst., April, 1918) advocated radical operation for tuberculosis of the seminal tract. The operation is begun through the incision for perineal prostatectomy. The prostate is drawn down by the tractor, and the diseased vesicles exposed. It is then determined how much of the prostate and vesicles needs to be removed. If the vas is to be removed, it is clamped and divided just above the vesicle. After removal of the tuberculous structures below, an incision is made in the groin and the diseased epididymis or testicle removed. The vas deferens is then drawn upon alternately above and below and thus detached from its connections and drawn out. One end may be left attached either to the removed epididymis or vesicle.

The Kidneys

Injuries of the Kidney.—*Rupture of the kidney* requires treatment to forestall the dangers inherent in hemorrhage, infection, hyperemic nephritis,

functional anuria, aneurism, urinary extravasation, and hydronephrosis. The great danger is from hemorrhage; and later from infection. When a diagnosis of rupture of the kidney is made the question of operation is of first importance. If the bleeding is but slight, as shown by the small amount of blood in the urine, the absence of swelling in the loin and the conditions of the pulse and blood-pressure, the patient should be kept quietly in bed, and placed on a small diet with little fluid, to keep down the blood-pressure. Ergot and adrenalin, perhaps, do harm. Rest in bed should be continued for at least ten days after all trace of blood has disappeared from the urine.

In cases in which the bleeding is more pronounced as evidenced particularly by the constitutional symptoms, immediate operation is indicated. The surgeon should not be deceived by the amount of blood in the urine; it may be reduced greatly by rupture of the pelvis of the kidney or by stoppage of the ureter with clots. Progressive anemia, severe pain, progressive swelling in the loin, and intraperitoneal bleeding are the symptoms which call for operation. Any of the others of these, combined with the first, calls for exploration. In recurring attacks of hematuria it is better to operate than to have the patient take the hazard of repeated losses of blood. Without operation the prognosis is much worse than with operation, even when including the mild cases.

The important things to determine urgent operation are whether the main vessels or the kidney pelvis have been torn or whether infection is present. Cystoscopy and ureteral catheterization are the most reliable means to determine these conditions.

The exploration should be by the methods described for nephrectomy and other attacks upon the kidney. If a small bleeding wound is found it should be sutured, and a drain carried down to the kidney. Lacerated vessels at the hilum should be caught and ligated, care being taken to tie only the bleeding vessels. If the pelvis of the kidney is blocked with clots, it should be incised, cleaned out and the wound closed after the bleeding has been controlled. Parts of the kidney which have been severed or nearly severed should be removed and the remaining wound covered in by sutures as much as possible. Drainage should be provided to carry away oozing urine and blood. Every effort should be made to save as much of the kidney as possible. The reason for removing part or the whole of the organ is irreparable damage to the blood supply of so serious a character as to cause necrosis. Escape of urine is not so serious, as drainage is capable of taking care of it. Tears of the pelvis should be sutured or drained with a tube and gauze.

When the circulation of the kidney is so damaged that the whole organ is going to be deprived of the blood supply necessary to keep it alive, it should be removed. Nephrectomy for wounds is, perhaps, resorted to too much. The two main objections to the operation are that (1) the kidney may be saved, and (2) there may not be another functionating kidney.

In cases of rupture of the kidney, complicated by injury of abdominal viscera and rupture of the peritoneum covering the kidney, the abdomen should be explored. This may be done through the wound in the loin, but it is much better to make an anterior abdominal section as giving better access to the abdominal viscera. If there is sufficient evidence of such injury the anterior route alone in most cases is the best. The kidney lesion can be dealt with and drainage carried out through the abdomen.

It may be summarized that more lives would be saved if a greater proportion of ruptured kidneys were exposed by operation, and if repair of the injury instead of nephrectomy were practised in a greater proportion of those

thus exposed. Secondary operation, done several days after the injury, when the tissues have become infiltrated with blood and urine, gives a much higher mortality rate than early operation. Early operation which exposes a kidney but slightly damaged need not be a serious matter; but deferred operation in the case of a seriously damaged kidney is extremely grave.

F. Voelcker (Beiträge zur klin. Chirurg., April, 1911, No. 3, Bd. lxxii) collected statistics which showed a mortality of 14.6 per cent. in 143 cases of rupture of the kidney treated by conservative operation, a mortality of 16.7 per cent. in 131 nephrectomies, and a mortality of 20.6 per cent. in 427 cases receiving no operative treatment. These figures are important when it is realized that operation is done only in the severest cases.

Wounds of the kidney, such as are inflicted by bullets and stabbing instruments, are amenable to the same principles of treatment as apply to rupture excepting that there is additional reason for exploration and drainage because of the danger of infection having been carried in. Commonly there is injury of other viscera. A small bullet wound, involving only the kidney, need be neither explored or drained if the symptoms of hemorrhage, urinary extravasation, obstruction or infection do not demand operation. These indications are described above under rupture of the kidney. The same may be said of stab and punctured wounds; operative exposure of the kidney is called for to meet the same conditions as in rupture of that organ. Such a wound involving only the pelvis should be drained with a small rubber tube in order to prevent urinary infiltration of the surrounding tissues. A bullet lodged in the pelvis should be removed as a stone. A bullet lodged in the substance of the kidney, even though it give no immediate trouble is apt to work its way to the pelvis and become covered by concretion. It should, therefore, be removed.

Infections and Inflammations of the Kidney.—*Perinephric abscess*, before operation, should be differentiated from appendicitis. The source of the infection should be discovered and eradicated. When an abscess is recognized it should be opened. The best incision is that described for exposure of the kidney (*vide infra*). The pus having been evacuated the wound should be held open and the kidney examined. When it is found that the disease is secondary to disease of the kidney, whatever else may be done, it is best not to perform nephrectomy until the patient has recovered from the effects of the febrile disease. A stone, working its way toward the surface of the kidney, may be removed, or a sinus leading to the pelvis may be enlarged and drained. If the general condition of the patient is not good, nothing more than incision and drainage of the abscess should be attempted.

Septic infarction, of hematogenous origin, may be discovered in operating for perinephric abscess. If the infarct is isolated, as occurs in the upper pole of the kidney, it may be enucleated with the finger and removed. The remaining cavity will be found lined with new connective tissue, and should be caused to collapse by packing it about with gauze.

The operative treatment of nephritis is still in an experimental stage. The operation consists in incising the capsule of the kidney the full length of the convex edge, and stripping it from the surface of the organ as far or nearly as far as the hilum (*decapsulation*). This leaves the raw surface of parenchyma, which becomes adherent to the perinephric tissues, and new vessels form. In some cases the organ becomes covered by a new capsule of fibrous tissue which may defeat the objects of the operation. The procedure appears to be of value in cases in which the congestion of the kidney produces tension, pain, and sometimes hematuria. In favorable cases the internal pressure is lowered and the circulation improved. The operation should not be per-

formed in cases of edema with cardiac insufficiency. Causing the decapsulated kidney to become adherent to the omentum may be of advantage. The operations may be done on each kidney a week or two apart or both may be operated on at the same time. Spinal anesthesia is well adapted to this operation, although light ether narcosis is commonly used.

While it may be difficult to understand how this operation can benefit nephritis, still experience shows that it does do good. In the acute nephritis of childhood, it seems to be of especial value. The operation is done when the child reaches a point at which improvement under hygienic treatment stops, or when hygienic treatment fails to bring improvement. So satisfactory have the results been in children that the surgeon is now warranted in saying that operation may save life in acute nephritis, and no child with this disease should be permitted to die without operation. In chronic nephritis in childhood the operation may prolong life, and it should be applied in cases which are not improving under hygienic treatment (see Operation of Decapsulation of Kidney, page 170).

Pyelitis (inflammation of the pelvis of the kidney) should be prevented by the prophylaxis of ascending infections. When produced by stone, the stone should be removed. Cystitis, bladder paresis, ureteral kinks, and other causative factors should be treated. Urethral obstruction should be relieved. Often cases of pyelitis are cured by cystotomy and permanent drainage of the bladder to remove urinary tension. Mild infections of the renal pelvis are benefited and usually cured by copious ingestion of water and the internal administration of hexamethylenamin in full doses. This drug is of decided value as a prophylactic in conditions which may lead on to pyelitis. In uncomplicated pyelitis it is desirable that the urine should be well diluted to minimize irritation and to keep the pelvis well washed out. Any obstruction to the escape of urine worsens the disease. If evidence of obstruction at the outlet of the pelvis or in the ureter is present the remedy is removal of the obstruction. Wandering kidney, producing angulation of the ureter, is a common cause to be treated. Obstruction due to gravel which does not yield to other measures may be treated by catheterization of the pelvis and irrigation. This accident is best prevented by keeping the specific gravity of the urine low.

In *chronic pyelitis* the best results are secured by passing a ureteral catheter to the renal pelvis and irrigating with silver solution. Such treatment should be preceded by irrigation with normal salt or boric acid solution, especially if there is much detritus. The operation may be done once or twice a week (see Renal Lavage, page 148).

In *suppurative pyelitis* a more serious condition is encountered. It should be treated by copious draughts of water and hexamethylenamin in full doses—a pint of water every hour and 3 Gm. (45 grains) of the drug daily. This failing, the renal pelvis should be rinsed out with silver nitrate solution. (1 : 500) once or twice a week. Other medicaments of value are benzoate of soda and methylene blue. Stoppage of the escape of pus is easily caused by lumpy detritus, and unless quickly relieved the suppurative process extends to the substance of the kidney. When the evidences of internal pressure in the renal pelvis appear in a case of pyelitis it should be relieved at once by the ureteral catheter. If catheterization of the pelvis is not attempted or does not succeed, then the kidney should be cut down upon and the pelvis incised. In such cases, pyelotomy is the operation of choice. If the kidney is not easily exposed and moved, then nephrotomy for drainage of the pelvis is indicated.

The *mild cases* in which the cause of infection is not known may be expected

to yield to rest, restricted diet, copious ingestion of water, hexamethylenamin, potassium citrate and mild diuretics, such as fluid extract of uva ursa and corn silk. If the urine is acid, potassium citrate, or sodium bicarbonate is indicated, unless hexamethylenamin is to be given.

Colon bacillus infection, if mild, will often yield to the above simple treatment. Cases which resist this treatment may be cured by *lavage*.

Colon bacillus vaccine is effective in conjunction with the local treatments. It should be given about every five days. The initial dose is 10 to 20 millions; this is gradually increased, and may reach one billion or more.

Renal lavage is rarely required in pyelitis, as most cases are curable without it. The mistake should not be made to attempt the treatment of pyelitis by lavage when there is an unremoved, constantly acting cause, such as stone, ureteral kink, valve, paralyzed bladder, urethral obstruction, pyonephritis, tuberculosis or syphilis. Acute cases and cases associated with ureteritis may be aggravated by the treatment. After the treatment there must be left free drainage through the ureter or the treatment is not worth while. Rarely will lavage succeed if there is an abscess in the kidney substance.

In *colon bacillus infection*, which does not respond to other treatment, lavage is called for. It is the most effective measure in these cases. The ureteral catheter is passed to the pelvis, and irrigation practised with a 1 per cent. solution of silver nitrate. From 5 to 10 c.c. may be injected. The pelvis should not be filled too rapidly, and the amount injected should not be too large, otherwise pain will be caused. If thick pus is present the pelvis must be washed out with salt solution before the injection is made. These treatments may be given every four, six, or eight days. Permanent drainage is often useful, and secured by leaving the ureteral catheter in place during the intervals between irrigations if the disease in unilateral.

The technic of this operation is best carried out by an experienced cystoscopist. In the female the simple, direct vision, endoscope or the electrically illuminated cystoscope may be used (see Cystoscopy, page 187). A small-sized ureteral catheter should be passed through the urethral instrument and thence by the aid of the eye into the ureter to the renal pelvis. If pus is present the pelvis should be washed out with warm salt or 2 per cent. boric acid solution. A small syringe may be used, but a funnel is better. The amount of fluid injected must vary. If the catheter is small the irrigation may be continuous, the fluid passing to the bladder outside of the catheter. The amount of dilatation of the pelvis will also determine the amount of fluid. Usually 8 c.c. (2 drams) can be injected without discomfort. Distention of the renal pelvis causes colic at once.

After washing out the pus, the medicated solution which has given the best results is nitrate of silver. Mild solutions (1 : 2000) are preferred by some. Others employ 1 and 2 per cent. solutions with satisfaction. Bichlorid of mercury, 1:20,000 gives good results. The chlorin-liberating antiseptics also are employed. Treatment may be given twice a week, and later once a week. Acute pyelitis and pyelitis with general infection should not be treated by this method.

Pyonephrosis (pus kidney, abscess of the kidney) usually means that treatment was not applied or failed to check a suppurative pyelitis, or that a hydronephrosis has become infected. The causative condition should first be looked to. Tuberculosis or other foci of suppuration should receive attention. Unless the disease is extensive, forms a palpable tumor, and it is manifest that most of the kidney tissue has been destroyed, conservative treatment should first be employed. Catheterization of the renal pelvis

through the ureter is of the utmost importance. It determines the questions of function and obstruction, and permits irrigation and medication of the abscess cavity. This failing, the kidney should be exposed, and the surgeon should decide whether to remove the whole organ without opening it or whether to incise and drain. Previous tests for function should have determined how much urine, if any, is being secreted by the diseased organ. If as much as one-third of the kidney is capable of secreting urine, an effort should be made to save it. This is done by incising the abscess or abscesses, removing stones, and inserting drainage tubes.

An abscess in the renal pelvis communicating with pockets in the renal substance, may be drained adequately by incision of the pelvis. The opening of abscess loculi and insertion of drainage tubes will fail to save the rest of the kidney tissue unless the pelvis and the ureter are patent. It is often the case that some obstruction in one or the other of these channels was the cause of hydronephrosis which became infected, and it is possible to remove the obstruction (see Hydronephrosis). The surgeon will also be influenced in the nature of the operation by a knowledge of the condition of the other kidney. It has happened that the only functionating renal substance a patient has possessed has been that which existed in a pyonephrotic organ. Under such circumstances there is but one course to follow, and that is to drain the pus collections and see to it that the pelvis and ureter are patent.

The surgeon should know the functional capacity of the other kidney. In a large proportion of cases it will be found that, as the diseased organ has had more and more of its substance retired from activity, a compensatory hypertrophy has been going on in the other organ, so that by the time all of the renal tissue in one kidney has ceased to functionate the other kidney is gradually assuming its function too, and an adequate amount of urine is being excreted by one organ. In such cases, a badly disorganized kidney will be removed. Also in cases in which it is clear that the kidney is not functionating to any considerable degree, even though an accurate knowledge of the other organ is not had, it must be assumed that, as the patient is alive, kidney function is going on somewhere, and the diseased organ may be removed. The cases in which the organ is riddled with multiple abscesses of various sizes, leaving little stroma between, may be treated by nephrectomy.

Many kidneys have been removed in which healing could have been secured by the simpler procedure of incision and drainage. A kidney can always be removed either at the first operation or later if it is found necessary to do so; but a kidney once taken out cannot be put back—at least it has not been done in man up to this time.

Tuberculosis of the kidney, requiring surgical treatment, is not the miliary variety, which is bilateral, but the chronic, caseating, nodular variety, which during the early period of its course is unilateral, and which becomes bilateral in scarcely more than a small majority of cases. In treating this disease the surgeon should be quite sure of his diagnosis, and bear in mind that it is possible for the kidney to eliminate tubercle bacilli without itself becoming permanently diseased. When the disease has become fixed in one kidney it should be gotten rid of, as its presence jeopardizes the ureter, bladder and other organs to tuberculosis.

The surgeon should not be deceived by remission of symptoms. The efforts of the tissues to surround the infection with a zone of connective tissue often result in temporary isolation of the disease. It may remain latent for a long time, and then renew its symptomatic expression.

There is ample ground to advocate nephrectomy as soon as the diagnosis is made. The hygienic and antitubercular treatment should be applied

here just as in tuberculosis in other organs. Inasmuch as the infection of the kidney occurs as a result of the effort of the body to eliminate tubercle bacilli, it will often be found that another focus exists somewhere else in the body. This is the reason why nephrectomy is so often followed by the appearance of lesions elsewhere. If the surgeon could be reasonably sure that there were no other foci, and that the other kidney were capable of assuming the whole kidney function, nephrectomy should be the treatment of choice; and if under these circumstances, he could know the location of the disease in the affected kidney, the extirpation of only the diseased segment would be the ideal procedure.

Modern diagnostic methods make it possible to perform these ideal operations in some cases. After exposing the kidney, before continuing with nephrectomy, if it is evident that a large part of the kidney is free from disease, the renal vessels may be clamped temporarily, and the organ incised through its convex border in order to discover the location of the tuberculous foci. Each of these may be removed and the split organ sutured. In some cases a tuberculous nodule may be seen on the surface and excised (see Partial Nephrectomy, page 167).

The objection to such resection is that it may fail to remove all of the disease; and usually this is the case. If tubercular infection still remains, resection is apt to be followed by a sinus which can not be made to heal until the kidney is removed. So commonly does this occur that, the majority of surgeons now advise against the partial removal of kidney structure for tuberculosis. Of course partial resection is the only operation that can be done in cases in which the other kidney has been removed.

The cases in which operation is unquestionably indicated are cases of mixed infection in which there is suppuration. Here the indications for operation are the same and the operation should be the same as for pyonephrosis. Before and after operation the general measures for the treatment of tuberculosis should be applied (see Tuberculosis, Vol. I, page 276).

A kidney which is affected with nodular caseous tuberculosis of a degree sufficient to be recognizable as tuberculous before operation, should be removed, provided the other kidney is not affected. In such a condition nephrectomy gives immediate relief of symptoms in the majority of cases, and a permanent cure in half of the cases operated upon. The mortality of operation ranges between 5 and 10 per cent. In skilled hands it need not be greater than 1 per cent.

Some surgeons prefer to bring the ureter out of the wound and attach it to the skin. If it is tubercular it may be injected with iodoform or phenol. In this position it heals and ceases to discharge. If it is dropped back into the wound, it may be responsible for forming a tubercular sinus. A few surgeons dissect it out and remove it. This is done by continuing the wound downward in front of the anterior-superior spine of the ilium. The former method is the better. Tuberculosis existing in the bladder is easily amenable to treatment after extirpation of the tuberculous kidney.

The modern trend toward the belief that all cases of unilateral tuberculosis should be subjected to nephrectomy as soon as the diagnosis is made, is because there is always danger of spreading of the infection by delay.

Descending infection is more easily cured than ascending infection. If the infection of the kidney is secondary to a primary focus in the epididymis there is great danger of involvement of both kidneys. Still if there is one sound kidney, even in ascending infection with involvement of epididymis and bladder, removal of the epididymis and kidney are indicated. This offers the best hope for cure of the bladder infection.

In cases of advanced disorganization of one kidney, tuberculous cystitis, and tuberculous ureteritis on the other side, removal of the disorganized kidney is most urgently called for. In such a case with stricture of the other ureter and beginning distention of the sound kidney, T. Rovsing (Annals of Surg., Vol. 56, 1912), besides removing the infected kidney, did a lumbar ureterostomy on the other side, and thus stopped the ascending infection; the stricture was dilated and the bladder treated, and when the cystitis had been cured the ureteral fistula was closed—all with a happy result.

In double ascending infection with stenosis of the ureter, distention of the pelvis, and the associated pain, lumbar ureterostomy relieves the pain and checks the ascending infection.

Syphilis of the kidney should receive the same constitutional treatment as syphilis of other organs (see Syphilis, Vol. I, page 283).

Tumors of the Kidney.—*Malignant tumors* (sarcoma, carcinoma, and hypernephroma) have a high mortality. They should be removed as early as the diagnosis can be made, before metastases have occurred or extension has made extirpation impossible. Before operating an examination should be made to discover metastases. The long bones especially should be examined for sarcoma. The presence of such secondary deposits contraindicate operation. The posterior operation through the loin is to be preferred; but in large tumors presenting anteriorly a transperitoneal operation will give the best access. The early recognition of tumor and improved technic have much reduced the mortality of the operation. In the hands of experienced surgeons the immediate death rate following operation has fallen in the past twenty years from 65 per cent. to 25 per cent., and the percentage of cures has similarly increased (see Tumors, Vol. I, page 323).

Benign tumors of the solid type are rare, compared with malignant growths. They should be treated by wide excision or nephrectomy just as though malignant in order that no chances shall be taken. *Papilloma* of the renal pelvis usually should be treated by nephrectomy and removal of as much of the ureter as is accessible because of the tendency of the disease to extend downward. In rare instances in which an isolated growth is discovered in the pelvis it may be treated by the high tension unipolar electric spark as in the bladder. *Aneurism of the renal artery* when discovered by posterior operation should be approached for treatment through the abdomen so that a ligature may be thrown about the artery between the aneurism and the aorta. The ideal operation in these cases is aneurismorrhaphy (see Vol. I, page 380), or arterioplasty.

Cysts of the kidney constitute a large part of its tumefactions. *Serous cysts* require simply to have their walls incised and contents evacuated. *Polycystic degeneration* of the kidney, on account of the fact that it is disseminated throughout the organ and usually involves both kidneys, is not amenable to treatment as a tumor. To extirpate one polycystic kidney has usually left another similarly diseased. Nephrectomy is contraindicated. Palliative measures should be employed. When such an organ becomes so large as to give pressure symptoms, it may be incised and drained to reduce its size. Nephrotomy is indicated also for pain, hematuria, uremia and oliguria in these cases. An infected polycystic kidney should be incised and drained. *Hydatid cysts* should be treated by enucleation of the cyst and its removal without rupturing it, if it is small. Larger cysts must be incised and drained. They should be approached by the posterior route (see Echinococcus Cysts, Vol. I, page 326). *Dermoid cysts* are best treated by nephrectomy.

Stone in the Kidney and Ureter.—The internal *medical treatment* of this disease is of value only in modifying the complications. Thus, urinary antiseptics, such as hexamethylenamin, methylene blue, benzoate of soda, and salol, inhibit infection, and tend to diminish the irritation about a stone; but no internal treatment has the power to dissolve renal calculi.

The treatment consists in removal of the stone. Small stones may pass to the bladder and thence through the urethra; but in the case of a stone that is lodged, or one that is producing obstruction or bleeding, operation should not be delayed. The appearance of pus in the urine is a strong indication for operation as it means that infection and destruction of the kidney is imminent. The fact that there is little pain with nephrolithiasis

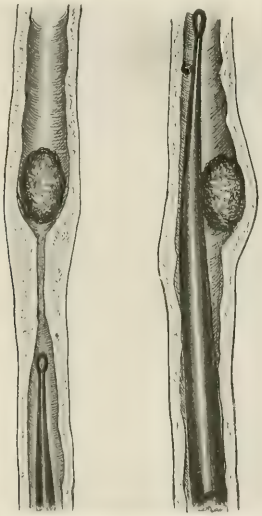


Fig. 1560.—Dilating Stricture of Ureter to Release Stone.
The ureteral catheter is passed through the stricture and beyond the stone.

should not deceive the surgeon; the condition is always a serious one, and the object of surgery should be to get rid of the stone before irretrievable damage has been done. Operation must be deferred or denied to the very old and infirm; and in the case of small stones in the ureter, time may be given for the stone to pass. To aid the passage of small ureteral stones, sterile olive oil may be injected into the ureter. In such cases in my service, my associate, Burton Harris, has been able with most happy results to inject oil above the stones, and thus cause their dislodgment.

Stones lodged above a stricture in the ureter may be liberated by passing a dilating ureteral bougie through the cystoscope. After dilating the tricture, the stone may be expected to escape (Fig. 1560).

Stones lodged at the lower ureteral orifice may require to be picked out with forceps, or the orifice may be dilated through the cystoscope. Stones

impacted in the ureter, causing pain, urinary obstruction, or infection should not be temporized with, but removed by operation (see Exposure of Ureter, page 171).

The operations for kidney stones are pyelotomy, nephrotomy, and nephrectomy. These operations should have been preceded by accurate diagnosis and examination into the functional activity of each kidney. Radiography and cystoscopy are essential for satisfactory treatment. The size, shape, and location of the stone will influence the manner of operation.

Briefly it may be stated that a small ureteral stone causing no obstruction usually does not require operation; a single stone in the pelvis is best removed by posterior pyelotomy; multiple stones lodged in dilated calices or abscess cavities should be reached by nephrotomy; nephrolithiases, with multiple abscesses destroying most of the kidney substances, are best treated by nephrectomy. An infected kidney which has been incised should be drained. The removal of stones from a non-infected kidney requires no drainage, and the wound may be sutured. Nephrotomy, instead of pyelotomy must be done in cases in which the kidney cannot be well exposed or moved. Primary nephrectomy for stone is rarely necessary; moreover, it is dangerous because of the fact that calcareous pyonephrosis often involves both kidneys.

Hydronephrosis.—The first aim of treatment should be to remove the cause of the obstruction which has produced the dilatation of the renal pelvis and kidney with retained urine. Diagnosis is the first step. Phimosis, stricture of the urethra, hypertrophy of the prostate, and tumor of the bladder, if present, should receive appropriate treatment. Partial stenosis of the ureter at either extremity, tumor or inflammatory exudate, compressing the ureter; or ureteral stone may require attention. Abnormal mobility of the kidney, giving rise to kinking of the ureter, should be treated. An anomalous renal artery, passing from the aorta behind the pelvo-ureteral junction, causing hydronephrosis, may require to be ligated and divided. An obstructing valve at the outlet of the renal pelvis may require to be removed. Stone, causing obstruction, should receive attention.

In determining what to do with the kidney after the obstruction is removed, the functional capacity of the two kidneys should each be known. When the cause of the obstruction is not known, the kidney should be exposed. If a valve of mucous membrane exists at the pelvic outlet, it should be removed and the wound sutured; or a transverse incision may be sutured longitudinally to obliterate the valve.

If inspection of its exterior does not reveal the cause to reside in mobility, tumor, accessory renal artery, or other remediable condition, nephrotomy or pyelotomy, depending upon the mobility of the organ, should be done. If stone or valve or other obstruction to the pelvic outlet is not found, drainage should be instituted. It is rarely advisable to proceed at once with nephrectomy unless little or no functionating kidney substance remains.

In the cases in which no cause has been discovered, a cure is effected in a large proportion of cases by simple incision and drainage. While a fistula exists, careful observations of the urines should be made in order that an estimate of the functional efficiency of the kidneys may be had. A nephrectomy may later be decided upon.

A greatly dilated renal pelvis may be treated by *pycloplication* (pleating it into folds) to take up the slack; or resection of some of its wall may be done. The practice of making a lateral anastomosis of the ureter to the dilated pelvis (*ureteropyelostomy*) has given good results, also division of the ureter and reuniting it to the lower part of the pelvic pouch. This latter expedient is to be recommended in dealing with stricture of the upper

end of the ureter. These anastomoses are made after the method of intestinal suturing (see Operations on the Ureter, page 173).

Nephralgia (Kidney Pain).—The treatment of this condition rests entirely in recognizing the cause and applying the proper relief. Stone and other urinary obstruction, bleeding from the kidney, wandering kidney, and nephritis are usually the factors to be dealt with. When attacks come on without warning, before a diagnosis can be made, the patient must be relieved by hot applications to the loins, codein or morphin. For a severe attack of *renal colic* a full-sized injection of morphin need not be delayed. Colic due to stone in the ureter may be relieved by injections of atropin, which acts by causing a relaxation of the spasmodically contracted ureteral muscles. Colic which persists, in cases in which curative treatment can not be applied at once, may be relieved by passing a ureteral catheter to the kidney pelvis, injecting through it cocain or alypin solution, and following this by injection of silver nitrate (1 : 1000). If the diagnosis is stone and the patient is not yet ready for operation, the ureteral catheter may be left in the renal pelvis, and 1 Gm. (15 minims) of a 4 per cent. solution of alypin or of a 1 per cent. solution of cocain may be injected several times daily to give relief.

Renal Hemorrhage.—This condition requires treatment of the cause of the bleeding. Traumatism, stone, tumors, and hemophilia have been discussed. The hemorrhage of the nephritides requires medical treatment. When the causative factor is not known or operation for its relief cannot be applied the bleeding may be stopped by injecting adrenalin solution through the ureteral catheter into the renal pelvis. Hemorhage following nephrotomy may require nephrectomy to save the patient.

Renal Fistula.—As a result of nephrotomy, pyelotomy, or the rupture of an abscess of the kidney, a fistula, discharging urine or urine and pus, may remain. Such urinary fistulæ continue to discharge so long as there is obstruction to the free drainage of urine through the ureter. Two things are desirable: to know the functional efficiency of the other kidney, and to remove the obstruction in the ureter of the affected organ. The latter is facilitated by ureteral catheterization, if it is possible, to locate the obstruction. If this is not done, and the fistula resists irrigation and suction treatment, the kidney should be cut down upon and examined. It may be possible to remove the obstruction (such as stone, valve, or stricture), and thus save the kidney. If the amount of kidney remaining is not worth saving, nephrectomy should be done. In many of these cases, the remains of the kidney are so involved in scar tissue that their removal is very difficult. When nephrectomy cannot well be performed, the renal vessels may be ligated through the abdomen by the same route as for exposure of the abdominal aorta. This operation causes atrophy of the kidney and cessation of discharge.

Wandering Kidney.—*Movable* or *floating kidney* when it is associated with a general enteroptosis should be treated along with that condition by hygienic measures. Persons who have movable kidney because of emaciation may have the perirenal fat restored and the organ again fixed by a liberal hydrocarbon diet. When no discomfort or disturbance of the function of the kidney is present, if the patient is assured that the movable mass is not a tumor, no further treatment may be required. When palliative treatment is indicated, relief may be secured by increasing the intra-abdominal pressure by means of an abdominal binder. Such a binder should be of stiff material, kept from wrinkling by means of whale-bones or steels, and broad enough to envelop the whole abdomen. That means that it should

extend from the pubes to the ensiform appendix. It should be so constructed as to make upward pressure in the lower part of the abdomen. Instead of a binder of cloth, better support can be secured with broad strips of adhesive plaster. Such plaster can be renewed about every four weeks, and, if smoothly and evenly applied, gives a decided sense of comfort (see Gastroptosis and Enteroptosis, Vol. II, pp. 710 and 616). Cases with a preponderance of nervous symptoms are the least amenable to surgical treatment. General hygienic measures should be the main reliance; operation is not apt to be of permanent help in the cases of floating kidney associated with general visceroptosis.

Perhaps the most effective support is to be secured by a properly constructed corset, coming well down over the pubes and ilia, making

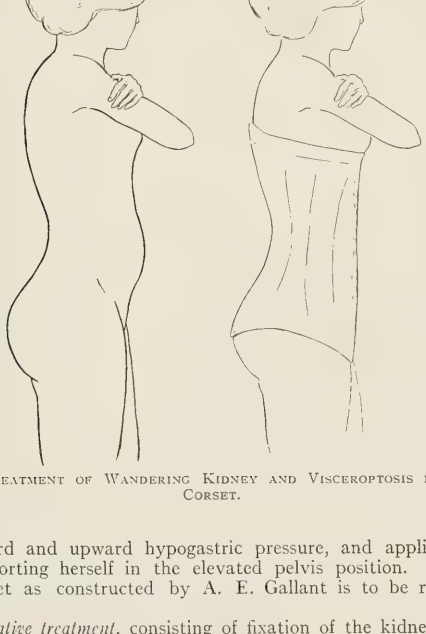


FIG. 1561.—TREATMENT OF WANDERING KIDNEY AND VISCEROPTOSIS BY MEANS OF CORSET.

flat, backward and upward hypogastric pressure, and applied with the patient supporting herself in the elevated pelvis position. For women, such a corset as constructed by A. E. Gallant is to be recommended (Fig. 1561).

The *operative treatment*, consisting of fixation of the kidney, should be reserved for cases not amenable to hygienic measures. The operation is called *nephropexy* (page 168). It should be done especially in cases in which renal crises arise from pressure or angulation of the ureter or renal pelvis. These cases yield most promptly to nephropexy. An operation which has given relief for a period may be followed later by recurrence of

the symptoms. In such cases operation may repeatedly be performed. The hazard of nephropexy is very small.

The Ureters

Injuries of the Ureter.—Rupture of the ureter requires the same treatment as penetrating wound of the ureter. Small wounds heal spontaneously, but in all cases of urinary extravasation the infiltrated tissue should be incised and exit for the escaping urine provided. A small wound of the ureter should be sutured. Complete division of the ureter is a much more serious condition. It is best treated by exposure of the ureter and making a ureteral anastomosis. If the division is low down, implantation of the upper segment into the bladder is easily done. If it is high up anastomosis with the renal pelvis may be done. In all cases, when possible, uretero-ureteral anastomosis is best. Longitudinal wounds heal better than transverse wounds; the former may be expected to heal spontaneously. Whenever the ureter is wounded through the peritoneum the latter should be stripped away from the ureter and its wound sutured. Drainage of the ureteral wound should be extraperitoneal. Loss of substance of the ureter, precluding anastomosis, requires implantation into bladder, bowel or skin, or a plastic operation. The latter may be accomplished by transplanting the vermiform appendix, Fallopian tube, or a segment of artery or vein. This is done by the technic used in blood-vessel suturing. Very commonly a ureteral fistula remains to be treated after gunshot and stab wounds because operation is usually done after urinary infiltration is well advanced, and the conditions for successful anastomotic operation are not good.

Ureteritis.—As this disease is usually caused by extension of disease from the bladder or kidney, the treatment should be prophylactic and consist in the treatment of the primary disease. In tuberculous ureteritis when the kidney is removed, the ureter also should be removed if tuberculous (see page 167).

Tumors of the Ureter.—Excision of the tumor or resection of the tumor-bearing segment is indicated. When the ureter has been divided and shortened too much for reunion, it must be treated by plastic operation, or implanted in the bladder or intestine, or the kidney removed, as described above for wounds of the ureter. A ureteral fistula, discharging all of the urine of one kidney, should not be tolerated.

Stricture of the Ureter.—In some cases a stricture may be dilated by ureteral bougies. This is most feasible at the extreme lower end. A bougie or catheter should never be forcibly pressed into the ureter. A narrowed bladder orifice may be enlarged by dilating forceps. The operation for stricture consists in incising the wall of the ureter longitudinally and sewing the wound transversely (see page 174). Impermeable and irremediable stricture may be treated by resection of the stricture-bearing segment and ureteral anastomosis.

Accidental Occlusion of the Ureter.—This accident has occurred in pelvic operations and especially in hysterectomy for large tumors, by a ligature embracing the ureter. The accident should not occur, but when it does the symptoms should be recognized at once, the wound opened, and the ligature removed. A clamp placed on a ureter, or other severe traumatism may cause *sloughing* and leakage, which should be treated at first by the administration of urinary antiseptics to prevent pyelitis, and later by the measures described for fistula.

Stone in the Ureter.—This condition has been discussed under renal calculus. In general, operation is rarely required; peristalsis of the ureter and the downward pressure of the urinary current will usually cause the stone to pass on to the bladder (see Stone in the Kidney and Ureter, page 152).

As a palliative as well as therapeutic measure when a patient is suffering the severe pain of ureteral colic due to stone, an hypodermic injection of morphin and atropin in generous dosage is most effective. Of still greater efficacy is papaverin which seems to have a selective action on the unstriped muscle of the ureter. A 2 per cent. solution is instilled into the ureter through a ureteral catheter in amounts of 5 c.c. The sulphate of papaverin is used. The drug causes relaxation of the ureter and permits painless passage of the stone.

Ureteral Fistula.—This condition, resulting from inflammation, ulceration, wound, rupture, or accidental injury, should be treated by the same general principles as renal fistula. Any obstruction below the fistula should be removed. The first suggestion of renal infection should be met by urinary antiseptics. If possible the ureter should be exposed and a uretero-ureteral anastomosis attempted after excision of the fistulous segment. Implantation in the bladder, or bowel, and finally nephrectomy are the operations of choice, if the other expedients fail.

OPERATIONS ON THE KIDNEY AND URETER

In operating upon the kidney it is highly desirable that the surgeon should have knowledge of the condition of the other kidney. This is particularly

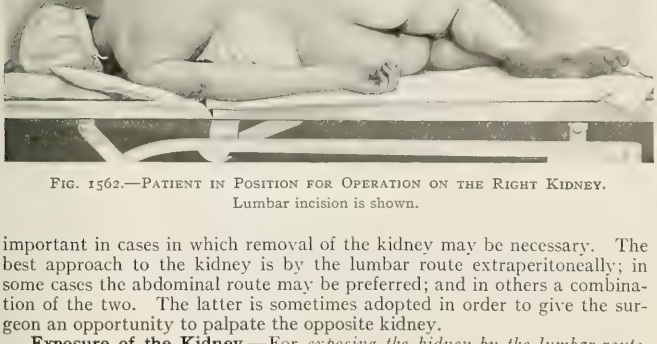


FIG. 1562.—PATIENT IN POSITION FOR OPERATION ON THE RIGHT KIDNEY. Lumbar incision is shown.

important in cases in which removal of the kidney may be necessary. The best approach to the kidney is by the lumbar route extraperitoneally; in some cases the abdominal route may be preferred; and in others a combination of the two. The latter is sometimes adopted in order to give the surgeon an opportunity to palpate the opposite kidney.

Exposure of the Kidney.—For *exposing the kidney by the lumbar route*, the *position of the patient* should be lying upon the sound side with sand pillows beneath the body to cause a convexity on the side of operation (Fig. 1562). This convexity lengthens the space between the last rib and the crest of the ilium, affording more room for approach.

The *incision* should preferably be slightly oblique, beginning 5 or 7 cm. (2 or 2½ inches) lateral to the spinous processes, near the center of the

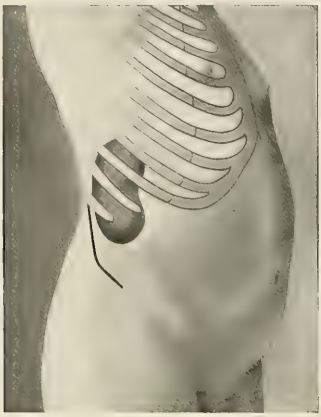


FIG. 1563.—OBLIQUE LUMBAR INCISION FOR EXPOSURE OF KIDNEY.

eleventh rib, at the outer edge of the sacrolumbar furrow. It passes downward and outward and forward to the crest of the ilium, and thence toward

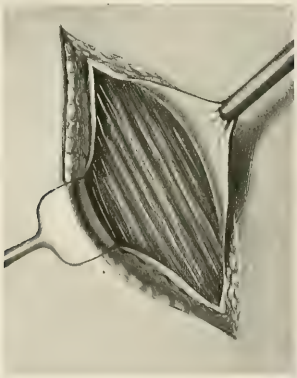


FIG. 1564.—POSTERIOR LUMBAR INCISION FOR EXPOSURE OF KIDNEY. The deep fascia has been divided and the erector spinae muscle exposed.

the anterior spine (Fig. 1563). The surgeon stands at the patient's back. When the ureter is to be exposed, the incision may be continued in front of

the anterior-superior iliac spine parallel to Poupart's ligament as far as necessary.

The incision crosses the last rib, and passes downward for about 6 or 8 cm. (2 or 3 inches), and then curves rather sharply forward as far as necessary. For uncomplicated nephrectomy it need make only the beginning of the lateral turn. The first incision passes down to the fascia covering the spinal muscles. The last rib should be freed from its connections with muscle and fascia along its lower border as far inward as the head. The pleura should be avoided and pushed upward. After the superficial fascia has been divided, the deep fascia overlying the muscles is incised (Fig. 1564). The external border of the latissimus dorsi is cut in the upper part of the wound.

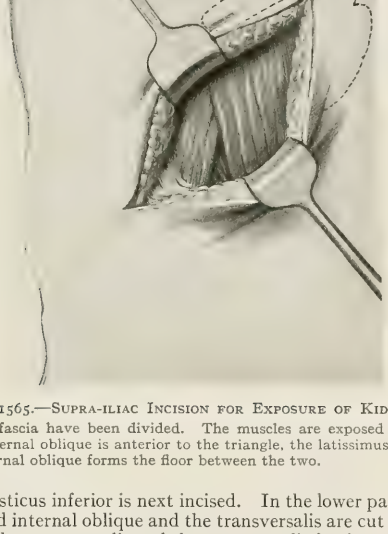


FIG. 1565.—SUPRA-ILIAC INCISION FOR EXPOSURE OF KIDNEY.

The skin and fascia have been divided. The muscles are exposed at the supra-iliac triangle. The external oblique is anterior to the triangle, the latissimus dorsi is posterior to it, and the internal oblique forms the floor between the two.

The serratus posticus inferior is next incised. In the lower part of the wound the external and internal oblique and the transversalis are cut through. The aponeurosis of the transversalis and the transversalis fascia are divided in the direction of the skin incision. The iliohypogastric and ilio-inguinal nerves, covered by the fascia, should be looked for in the lower part of the wound and avoided. The twelfth dorsal nerve, lying between the internal oblique and transversalis in the upper part of the wound, should be avoided.

It is entirely possible to make this approach largely through the supra-iliac triangle. The latissimus dorsi may be retracted backward and the external oblique forward (Fig. 1565). If necessary some of the fibers of the former muscle may be divided.

The kidney is approached to the outer sides of the quadratus lumborum and erector spinæ muscles, which form much of the inner wall of the wound. They need not be cut. When a small approach suffices, it is possible to dis-

pense with division of any muscles, except fibers of the latissimus dorsi and serratus posticus inferior; separation or splitting of the other muscle fibers and retraction suffices.

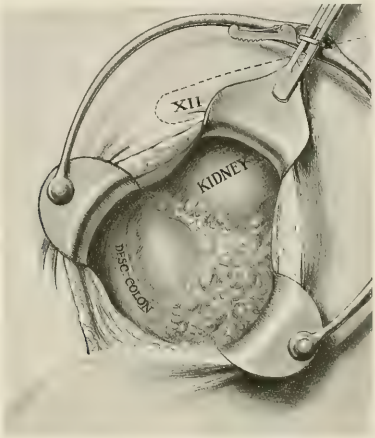


FIG. 1566.—KIDNEY EXPOSED.
The muscles are seen widely separated in the supra-iliac triangle.

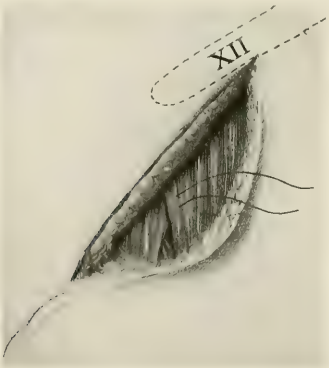


FIG. 1567.—CLOSING SUPRA-ILIAC TRIANGLE AFTER OPERATION ON KIDNEY.

As soon as the transversalis fascia has been divided the perirenal fat comes into view. Strong retraction of the wound edges is applied. By retracting the erector spinæ muscle inward and the last rib upward and out-

ward, free access is gained. The fat about the kidney is separated by blunt dissection, or, if very abundant, some of it may be removed. The fatty capsule proper of the kidney is discovered as a special layer. It is grasped by two pairs of broad-nosed forceps, lifted forward, and divided. Through the opening thus made the kidney is seen, lying in the depth of the wound. It is recognized by its dark purple color (Fig. 1566).

If, after division and retraction of the muscles and their fascia, the perirenal fat does not bulge into the wound, it may be made to do so by an assistant making backward pressure on the front of the abdomen. If the position of the kidney is high the incision must be carried up to the under border of the last rib. It is well to know how many ribs the patient has. If the

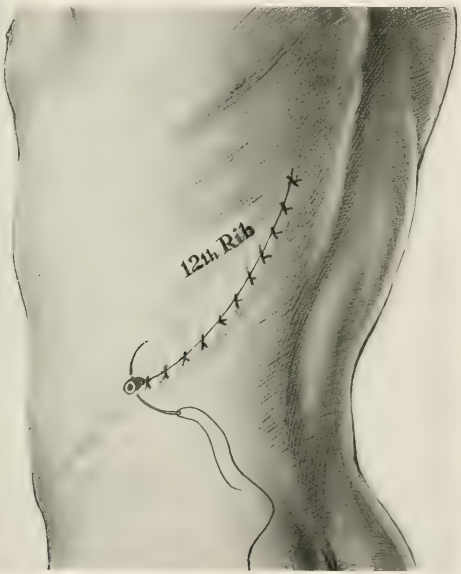


FIG. 1568.—CLOSURE OF NEPHRECTOMY WOUND, WITH FIXATION OF URETER IN LOWER EXTREMITY OF WOUND, AFTER MAYO.

eleventh rib is the last, there is danger of wounding the pleura if the incision is made as high as possible. If necessary to gain more room, the last rib may be resected subperiosteally and the pleura protected from injury. Before proceeding with the operation upon the kidney, all bleeding vessels should be controlled and clamps which narrow the wound removed.

The kidney once exposed, may be lifted into the wound with two fingers. Any excess of perirenal fat hindering its exposure should be cut away. The peritoneum should be looked for and avoided.

The lumbar route is the safest and best for exposure of the kidney, and is to be preferred in most cases excepting those of large tumor. By keeping

close to the outer border of the quadratus lumborum there is little danger of wounding the peritoneum. The colon which may crowd into the wound should be avoided. If it becomes necessary to examine the other kidney during the operation, the transversalis muscle is divided sufficiently far forward to expose the peritoneum, which is opened well away from the colon, and the hand passed into the abdomen and over to the opposite kidney. If the peritoneum is opened it should be closed by suture.

For closure of the wound, the parts are allowed to drop back into place. The lumbar fascia is sewed. The divided muscles are held with a few sutures of catgut; and the superficial parts closed with silkworm-gut.

If the kidney has been exposed by separating the muscles through the supra-iliac triangle, the lumbar fascia is sutured, the muscles are allowed to

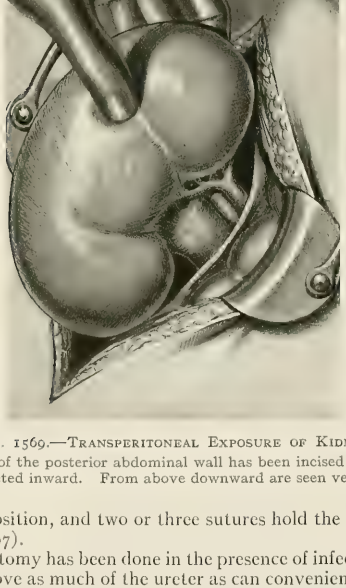


FIG. 1569.—TRANSPERITONEAL EXPOSURE OF KIDNEY.

The peritoneum of the posterior abdominal wall has been incised external to the colon and the bowel retracted inward. From above downward are seen vein, artery and ureter.

drop back into position, and two or three sutures hold the muscles across the triangle (Fig. 1567).

If the nephrectomy has been done in the presence of infection of the ureter, it is wise to remove as much of the ureter as can conveniently be taken away with the kidney, and stitch the distal stump of the ureter in the lower end of the wound (Fig. 1568). This provides drainage for the infected ureter and prevents the formation of a chronic sinus which is quite sure to follow if the stump of the ureter is left buried in the wound.

The *exposure of the kidney by a subcostal incision* is of service in some cases. This is a muscle-splitting operation, and is especially applicable in nephropexy. An incision is carried below the edge of the ribs about 1.3 cm. (½ inch). It begins at the anterior edge of the latissimus dorsi and passes

forward parallel with the ribs for about 10 cm. (4 inches). The fibers of the three flat muscles are split.

For *exposure of the kidney by the abdominal route*, the patient lies upon the back, and the abdomen is opened through the outer part of the rectus sheath, or through the linea semilunaris. The incision should be (10 or 12.5 cm.) 4 or 5 inches long, and have its center opposite the umbilicus. The colon is retracted inward and the posterior abdominal wall exposed between the ascending or descending mesocolon and the lateral abdominal wall. On the right side, by passing the hand to the under surface of the liver on the outer side of the gall-bladder, unless adhesions are in the way, the kidney is felt. The left kidney is more easily brought within touch. It is felt at the outer side of the descending colon. The division of the peritoneum to expose the kidney should be made vertically in front of the organ, always to the outer side of the colon, and as far away from the mesocolon as it can conveniently be made, as wounding of the mesenteric vessels may lead to gangrene of the bowel. Before closing the abdomen the peritoneal opening in front of the kidney should be sutured. If drainage is necessary, a counter-opening should be made in the loin (Fig. 1569).

For *exposure of the kidney by the combined extraperitoneal and transperitoneal method* a long vertical incision is made, 2.5 or 5 cm. (1 or 2 inches) or more to the outer side of the rectus muscle. This is carried down to the peritoneum. The peritoneum is not opened but is separated by blunt dissection from the rest of the abdominal wall. This separation is carried on until the kidney is reached. For the removal of large tumors the peritoneum may be incised as the kidney is approached. This operation is of value when a large opening with free access is required for dealing with large masses.

Another method is by a transverse incision extending from the erector spinæ muscle to the outer border of the rectus, beginning just below the last rib.

Exploratory Puncture of the Kidney.—This operation is falling into disuse because of the advances made in ureteral catheterization and radiography. When required to discover stone or fluid, a solid or hollow needle is thrust into the kidney after it has been exposed and steadied by one hand. The puncture is best made from the convex border toward the renal pelvis. Before it is made the position and shape of the kidney should be well in hand. Puncture may be made in the side of the organ. Several punctures may be made without apparent harm to the organ.

Puncture of the renal pelvis may be done after clearing the field and identifying the renal vessels. The pelvis should be steadied by two thin forceps. Through such a puncture a sound may be passed down the ureter for diagnostic or therapeutic purposes. After puncture of kidney or ureter, any indicated operation is proceeded with. If pus is encountered drainage should be used. After puncture of the pelvis a drain should be left in the wound as far as the pelvis. When no drainage is used the wound of approach should be closed by layer sutures.

Nephrotomy.—Incision of the kidney is done for the removal of stone or fluid, for the relief of tension, and for exploration. Lumbar exposure of the kidney is best. The kidney is drawn down from under the rib and lifted into the wound. The incision should be made directly into the thinnest part of a fluctuating area. If an object of attack is not palpable the incision is best made with its center a little posterior to the convex border of the kidney and curving so as to have its two ends at the convex border (Fig. 1570). Even with this incision there is considerable bleeding. Hemorrhage may be controlled by the two hands of an assistant compressing

with a flat pad the two sides of the wound; or a soft padded clamp may be applied temporarily. Wherever the incision is made it should be in the direction of radiation from the center of the renal pelvis.

For dividing the kidney, the use of *silver wire* has some advantages. By passing a wire into the substance of the organ, and making the incision by cutting through with a loop, less bleeding takes place. The capsule must first be incised.

No. 3 or 4 silver wire is used. The wire incision should be planned to lie at the ends of the blood-vessels. The chief blood supply is found on the rounded side. The flattened side has the smaller vessels. A notch usually marks the limit of the larger vessels. The wire is passed with a large blunt needle. It is caused to cut through the kidney by tightening it, and making a sawing motion.

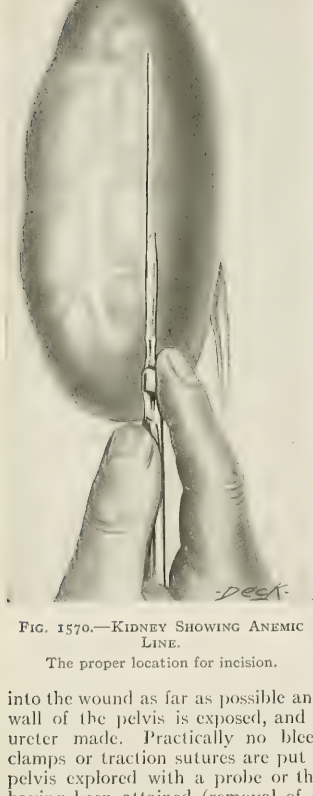


FIG. 1570.—KIDNEY SHOWING ANEMIC LINE.
The proper location for incision.

If an aseptic operation has been done, and there is no obstruction to drainage through the ureter, the kidney wound may be sewed. This should be done with fairly heavy catgut, passed deeply enough to embrace a good mass of tissue. The sutures need not be tied very tightly as slight pressure controls hemorrhage (Fig. 1571).

In case of suppuration being found, a drainage tube should be left in the infected cavity. If the wound in the kidney is much larger than is needed for the accommodation of the tube, its two ends may be sutured. When no drainage is used, the wound of approach should be closed by layer sutures, excepting the middle of the wound which should accommodate the exit of a drain from the outside of the kidney. The object of this drain in clean cases is for drainage not only of the perirenal wound cavity but also to carry off urine escaping through the kidney wound.

Pyelotomy.—The pelvis of the kidney is exposed for incision by the lumbar route. The fatty capsule of the kidney must be well retracted or removed and the kidney brought out into the wound as far as possible and steadied by the hand. The posterior wall of the pelvis is exposed, and an incision from the kidney toward the ureter made. Practically no bleeding follows the incision. Two small clamps or traction sutures are put on the lips of the wound, and the renal pelvis explored with a probe or the finger. The object of the operation having been attained (removal of calculus, probing of ureter, removal of valve, etc.), the wound in the pelvis is closed by a suture of fine chromic

gut. This should be applied as in intestinal suturing. But one suture need be used. It should penetrate all except the mucous coat.

The advantages of pyelotomy over nephrotomy for removing stone from the pelvis is that there is less bleeding, the kidney parenchyma is not damaged, and better access to the ureter is secured. The disadvantages are that the kidney has to be brought further out of its bed and the danger of urinary fistula is greater. A drain should always be carried down to the pelvis after pyelotomy.

Nephrectomy.—The removal of the kidney should not be attempted unless the surgeon is aware of the existence of another functionating kidney. However, if the operation exposes a kidney with little or no remaining parenchyma the surgeon may know that there is another functionating organ or the patient would not be alive. Nephrectomy may be performed through any of the routes of approach. The one having the largest field of application is through the oblique lumbar incision (page 157).

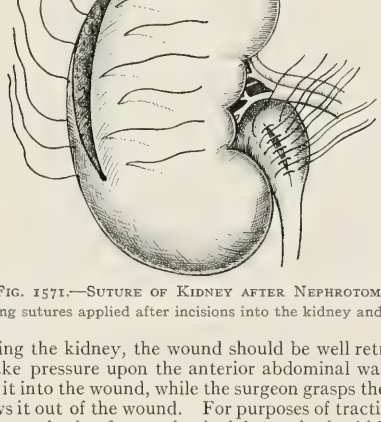


FIG. 1571.—SUTURE OF KIDNEY AFTER NEPHROTOMY.
Showing sutures applied after incisions into the kidney and pelvis.

After exposing the kidney, the wound should be well retracted, an assistant should make pressure upon the anterior abdominal wall in front of the kidney to push it into the wound, while the surgeon grasps the organ, denuded of fat, and draws it out of the wound. For purposes of traction broad hooked forceps may be used; the fingers, hooked beneath the kidney, are better. Fat should be cleared away from the pedicle by blunt dissection, and, if possible, the kidney should be delivered outside of the wound. Too much traction may tear the vein or even the vena cava.

The pedicle is the important structure. If possible, the surgeon should recognize the vessels. At least they should be differentiated from the ureter. They should be tied preferably in two groups—the artery in one and the vein in the other. Accessory vessels should be ligated separately. The ligatures on the vessels should not include the ureter or pelvis. In septic cases especially, such inclusion is highly dangerous Ligatures of chromic catgut are used. They are best carried on an aneurism needle. If the vessels can be seen clearly, each should be tied separately. Two sets of ligatures may be applied and the vessels cut between or one or two clamps may

compress the renal side of the vessels. Enough stump should be left to the vessels to insure the ligature against slipping. Slipping or giving way of a ligature is the great danger of nephrectomy. The ureter should be ligated separately (Fig. 1572). In infected cases, the stump of the ureter should be cauterized. In tuberculosis, it should be dissected out.

When the kidney is surrounded by much scar tissue, nephrectomy is facilitated by splitting the capsule of the kidney and shelling out the organ from its fibrous bed. In cases with adhesions, dealing with the pedicle is not an easy matter; often the vessels cannot be ligated but must be clamped and the clamps left on and included in the dressing. Even in uncomplicated cases it may sometimes be necessary to clamp the vessels of the pedicle and leave on the clamps. By the end of three or four days a clot of sufficient

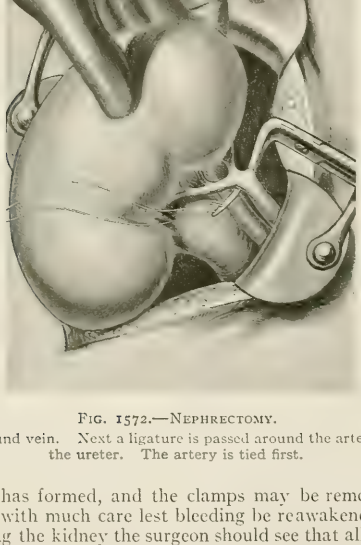


FIG. 1572.—NEPHRECTOMY.

Passing ligature around vein. Next a ligature is passed around the artery, and last around the ureter. The artery is tied first.

firmness usually has formed, and the clamps may be removed. Their removal should be with much care lest bleeding be reawakened.

After removing the kidney the surgeon should see that all bleeding is controlled. The operation leaves a large cavity, and even in uninfected cases drainage for a few days is to be recommended. A cigarette or rubber drain should be allowed to escape at the middle of the wound and the rest of the wound closed. Fascia and muscle should be sewed together and the rest of the wound closed by suturing each tissue to its like.

In operating for malignant tumor, the surrounding fatty tissue should be taken away with the kidney. If the pleura or peritoneum are accidentally opened the rent should be closed at once by a purse-string or continuous catgut suture. In the event of wounding the colon, it should be sutured.

W. J. Mayo directed attention to the danger of wounding the duodenum

during removal of the right kidney. Before the patient becomes exhausted from discharge from a duodenal fistula, an interior operation should be done, closing the duodenal wound, and ending with a jejunostomy for temporary feeding.

Nephrectomy for tuberculosis requires some special considerations. In a small proportion of cases of tuberculosis of the kidney the ureter is tuberculous. The ureteral disease has usually been recognized because of the existence of stricture. In these cases at least all of the ureter above the stricture and including it should be removed along with the kidney. If the ureter is not removed, it should be injected with 95 per cent. phenol. The most effective injection of a ureter, occluded by stricture, is with 0.3 to 0.6 c.c. (5 to 10 minims) of phenol, and ligation of the ureter to cause retention of the fluid. No drainage should be used.

W. J. Mayo noted the disadvantages of drainage after nephrectomy for tuberculosis. Drainage is very apt to be followed by secondary infection of the ureteral stump, resulting in sinus formation which is persistent and serious. If the wound is accidentally soiled with tuberculous matter it is better to wash it out, sterilize the ureter, and close the wound tightly. In nephrectomy upon kidneys which have lost their function or become closed sacs the ureter is best treated by sterilizing it, and closing the wound without drainage.

In cases with mixed infection and secretion of urine, the ureter, if left will sometimes develop a sinus, even though it has been sterilized, tied, and the wound closed. Mayo recommended that in these cases the stump of the ureter should be attached to the skin at the lower end of the incision. This permits the external discharge of ureteral contents. This is usually called for in early cases with mixed infection and in which urine secretion had continued, and maintained a patent ureter. Usually after this treatment the ureteral stump will discharge for a few days and then heal spontaneously.

Partial nephrectomy is something done for the removal of a badly lacerated pole of the kidney, for tumor, localized abscess, or other condition in which only part of the kidney is diseased. It is best that a wedge-shaped piece should be removed so that closure of the wound by sutures can be made more neatly. During such an operation bleeding may be controlled by a temporary clamp on the pedicle.

Nephrectomy by morcellement (taking away the kidney in pieces) is sometimes advisable in cases with dense perirenal adhesions. Part of the organ is grasped by strong clamps and the excluded segment cut away with scissors or cautery. This is continued bit by bit, gradually working toward the hilum. In this way a pedicle is formed which may easily be ligated.

Transperitoneal nephrectomy is begun the same as an abdominal section (Vol. II, page 504). Through the incision in the peritoneum on the outer side of the mesocolon the perirenal fat is incised. The fingers are passed in and the kidney enucleated by blunt dissection. The renal vessels are identified by blunt dissection. An aneurism needle, carrying a catgut ligature, is passed around the artery and tied. The vein is best tied last. A ligature may be applied to both vessels on the renal side and the vessels cut between the ligatures. If there is not room for the distal ligature, a clamp may be used. The ureter should be ligated doubly and cut between the ligatures. The mucous membrane of the stump of the ureter should be cauterized. The kidney is then removed from its bed. Bleeding is carefully controlled by ligatures. A counter-opening is made by thrusting a blunt instrument backward and outward through the muscles of the loin and cutting down upon it through the skin. Through this opening a long clamp is passed which grasps a drainage tube and draws it into the opening. An

infected or occluded ureter should be drawn out into a posterior wound and fixed there by a suture.

After placing this posterior drainage into the retroperitoneal space, the peritoneal wounds and the abdominal opening are closed as usual. When anterior drainage is to be used the edges of the posterior peritoneal opening should be sutured to the edges of the anterior peritoneal opening, thus shutting off the general peritoneal cavity from the wound.

Nephropexy.—This operation is performed to fix in place a too movable kidney. The kidney is exposed by the lumbar incision. The fatty capsule is divided. It is best that the fat should not be removed but pressed downward to act as a shelf for the kidney. The fibrous capsule proper of the kidney should then be divided on its posterior surface by a longitudinal incision running nearly the whole length of the organ. This incision is crossed at either end by an incision at right angles to it. This last is about 2.5 cm. (1 inch) long. Two long flaps of fibrous capsule 1.3 cm. (½ inch) wide are stripped back, leaving exposed a parallelogram of renal parenchyma 2.5 cm. (1 inch) wide. Sutures of chromic catgut are passed through the capsule and reflected capsule, about eight in number, in such a way as to keep the flaps turned back. These sutures are passed through the transversalis fascia as high up in the wound as possible, thus sewing the kidney fast to the wound and leaving a broad raw surface to become adherent (Fig. 1573). The defect of many operations is that the kidney is not anchored high enough. The kidney should be raised up into the desired position before the sutures are passed. As they are tied the kidney is drawn back against the posterior abdominal wall. The deep fascia is then sutured, followed by suture of the muscles and the rest of the wound. Drainage is not used (Fig. 1574).

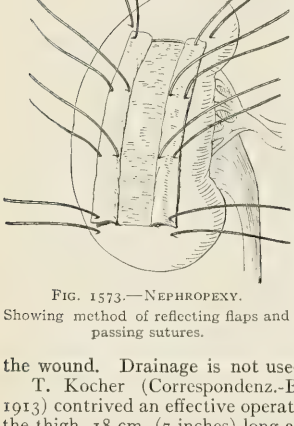


FIG. 1573.—NEPHROPEXY.
Showing method of reflecting flaps and passing sutures.

T. Kocher (Correspondenz.-Blatt f. Schweizer Aerzte, xliii, May 3, 1913) contrived an effective operation whereby he took a piece of fascia from the thigh, 18 cm. (7 inches) long and 10 cm. (4 inches) wide, to make a hammock. A slit, 4 cm. (1½ inches) long is made in the middle, to receive the lower pole of the kidney. The kidney is rested in this as in a hammock. The corners of the fascia are sutured to the wound, and the kidney fixed to the hammock of fascia by a few sutures (Fig. 1575).

Instead of using a hammock of fascia two strips may be thrown around the poles of the kidney, and sutured. Such strips may be held by sewing them to the capsule.

W. Bartlett (Jour. Am. Med. Assoc., 1917) devised an operation having as its principal the fact that the perirenal fat normally supports the kidney in position. The operation consists in inverting the fatty capsule, sewing it into a ball, and plugging with it the cavity formed by the replacement of the kidney. The fat being removed from the anterior surface of the muscles, the kidney becomes adherent.

Extracapsular fixation of the movable kidney was advocated by C. A. L.

Reed (Jour. Am. Med. Assoc., Sept. 17, 1910). The fatty capsule enclosing the kidney is separated from the abdominal wall but pains are taken not to separate it from the fibrous capsule. The fat is wiped away by stroking the capsule with gauze, leaving the trabeculæ of connective tissue. Friction by

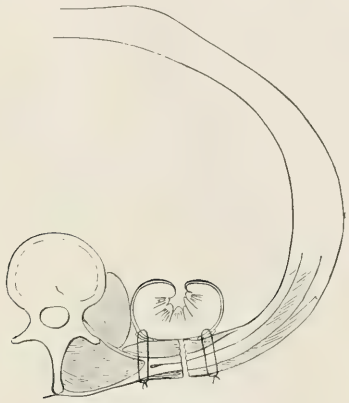


FIG. 1574.—NEPHROPEXY.
Transverse section showing manner of fixation of kidney to the lumbar structures.

means of gauze is applied to the fibrous capsule over the upper part of the kidney for the purpose of creating irritation. Any remaining perirenal fat attached to the abdominal wall above is wiped away, and the kidney, cov-

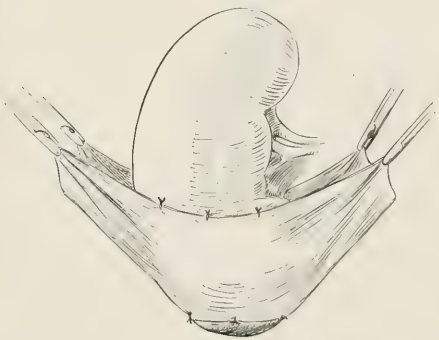


FIG. 1575.—SUSPENSION OF THE KIDNEY IN A HAMMOCK OF FASCIA.

ered above the connective-tissue meshwork, is pressed up into its natural bed. The meshwork of the fatty capsule is then divided transversely about 2 cm. (¾ inch) below the kidney. This stump of fatty capsule upon which the kid-

ney rests is attached by chromic gut to the upper margin of the operation wound. The lower stump of fatty capsule is then sutured to the lower margin of the wound. The remains of the fatty capsule are thus elevated to form a shelf upon which the kidney rests. The kidney, through the fibrous trabeculæ of the fatty capsule becomes adherent to the posterior abdominal wall in the desired position. The union is more elastic and normal than in the operations which fix kidney substance directly against the parietes.

Anterior transperitoneal fixation of the movable kidney has much to recommend it. The abdomen is opened through the anterior abdominal wall external to the rectus muscle. The kidney is exposed by incision of the peritoneum external to the mesocolon. The kidney is isolated, brought forward into the abdomen, and the fatty capsule pressed downward. The kidney is then placed in its retroperitoneal bed, after irritating the fascia posterior to it by means of a scraping instrument. The kidney now has in front of it the peritoneum and behind it the transversalis fascia without the intervention of fat. It is so placed that the upper pole shall be tilted toward the spinal column, thus preventing pressure or kinking of the ureter. In order now to make a shelf for the kidney to rest upon the peritoneum is sewed to the transversalis fascia by a couple of stitches just below the kidney. This fixes the kidney which rests upon the mass of fat which has been displaced downward from the capsule.

This operation has the advantages that attention may be given to the vermiform appendix, bile ducts or gall-bladder, any of which may be pathologic in cases of suspected wandering kidney. This anterior operation is worthy of more attention than has been bestowed upon it up to the present time.

Decapsulation of the Kidney (Nephrolysis).—The kidney is exposed by the lumbar incision, and brought into the wound. The fatty capsule is pressed back, and an incision just through the fibrous capsule is made the whole length of the organ. The capsule is stripped back toward the hilum from a half or three-quarters of the surface of the organ, and left curled back inside out. Sutures of chromic catgut then catch the angle of reflection and attach the kidney to the transversalis fascia. As the sutures are tied the organ is drawn back against the wound as in nephropexy. The external wound is then closed.

This operation constitutes nephropexy as well as decapsulation. It was first done by T. Rovsing and described by him in 1895. Rovsing laid especial emphasis on removing the fatty capsule if it shows fibrous degeneration.

The operation seems to be of benefit in both chronic and acute nephritis. Harrison (Lancet, London, 1896, 1, 18) operated on acute nephritis by incising the kidney, and reported cures. Edebohls (Med. News, 1899, 74, 481) incised the capsule and stripped it back in chronic nephritis, and popularized the operation. Soon the operation was being done with gratifying results in acute nephritis. Abundant cases are now reported showing recoveries secured by this operation in cases of acute nephritis which were rapidly advancing to a fatal termination. It is in the acute cases with extreme congestion that the operation seems to save life. In these cases when the capsule is incised the swollen kidney bulges through it and tension is relieved. The operation is indicated only in the acute cases in which there is acute congestion as indicated by intoxication and marked diminution of the amount of urine.

Theoretically it is difficult to see how the operation can be of benefit in chronic nephritis, still it does a large proportion of these cases good. Children seem especially benefited, but adults also are helped.

The operation has been done enough to have given it a position in surgery. It is capable of saving life and giving a permanent cure in the acute nephritis of childhood. While the operation cannot be expected to cure chronic nephritis, still it may prolong life in a considerable proportion of cases.

Operation for Valvular Obstruction in the Renal Pelvis.—This operation is required usually in the treatment of hydronephrosis. The renal pelvis is opened by a posterior incision if the kidney has been exposed in the rear. The valve is cut through with a cautery knife or with scissors. Bleeding may be checked by the cautery or fine suture of catgut. The pelvic wound may be sutured. A drainage tube should be carried down to it whether it is left open or closed.

Exposure of the Ureter.—The ureter may be exposed throughout its whole extent by extraperitoneal operation. Operations for exposure of the

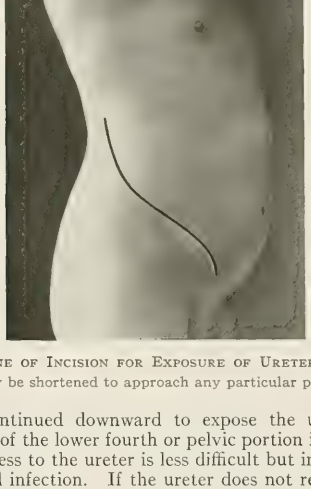


FIG. 1576.—LINE OF INCISION FOR EXPOSURE OF URETER AND KIDNEY.
This incision may be shortened to approach any particular part of the ureter.

kidney may be continued downward to expose the ureter. The extraperitoneal exposure of the lower fourth or pelvic portion is the most difficult. Transperitoneal access to the ureter is less difficult but introduces the extra-hazard of peritoneal infection. If the ureter does not require to be opened the abdominal route is best. In experienced hands the abdominal route may be the most desirable for any operative attack upon the ureter if the operation is concluded by providing extraperitoneal drainage to take care of any leakage and by securely suturing the peritoneum over the ureter.

The intrapelvic portion of the ureter may be reached by the transperitoneal route, by sacral resection, by incision through the rectum, bladder, vagina, or male perineum. In general the route to be preferred is external to the peritoneum, and continuous with that by which the kidney is exposed.

Retroperitoneal exposure of the ureter and kidney is secured by an incision, beginning at the junction of the lower border of the twelfth rib and the outer border of the erector spinæ muscle, passing downward and forward to the iliac crest about 2.5 cm. (1 inch) behind the anterior-superior spine, thence

curving in front of the spine and passing parallel with and about 2 cm. (¾ inch) above and Poupart's ligament, ends opposite its lower third (Fig. 1576). The position of the patient is as for exposure of the kidney.

The exposure of the kidney is accomplished by the steps described above for that operation (page 157). The continuation of the incision downward should split the fibers of the external oblique and transversalis and cut those of the internal oblique. Upon reaching the extraperitoneal connective tissue the peritoneum should be pushed inward and stripped up from the underlying transversalis fascia. The inner lip of the wound should be retracted inward, carrying with it the stripped-up peritoneum. The blunt dissection of the peritoneum from its subperitoneal tissue is best accomplished by the thumbs, aided by a sponge of gauze.

As the lower end of the wound is reached the patient should be placed in the lowered-head position of Trendelenburg, but still kept rotated upon the well side. Care should be taken not to tear the peritoneum. As the operation proceeds, the iliacus and psoas muscles, the spermatic cord, and the vessels of the colon are exposed. The ureter is found closely adherent to the peritoneum. It should be traced down to the iliac vessels in front of which it lies. The bifurcation of the internal iliac vessels is the guide to the ureter. It lies in front of this, adherent to the peritoneum. A few connective-tissue fibers may require to be cut to separate them. When the ureter is drawn upon it stands out like a ridge, and may be followed to the bladder.

The epigastric vessels should be doubly tied and divided or retracted downward. The spermatic cord or round ligament should be retracted inward. The bifurcation of the common iliac vessels is exposed. In the male the vas deferens is come upon lying between the ureter and bladder. In the female the cervix uteri and vagina lie internal and behind. All of this dissection can be made with patience. There should be but little bleeding or depression.

Exposure of the lower end of the ureter alone may be accomplished by an incision from the top of the anterior-superior spine of the ilium to the top of the symphysis pubis. The external oblique is split in the line of the incision. The internal oblique and transversalis also should be split. The fibers of these muscles and their fasciæ should be retracted as much as possible and spared division. The rectus should not be divided but retracted inward if the room is needed. The deep epigastric vessels may be retracted downward or doubly ligated and cut. The dissection is carried down to the peritoneum and proceeded with as in the above operation.

E. S. Judd (Annals of Surg., 1914, vol. 59) devised an *extraperitoneal suprapubic approach*, which seems especially useful for the removal of small stones in that part of the ureter which lies in the bladder wall. The patient is placed in the lowered-head position and the peritoneum is exposed by a median incision extending from the symphysis to the umbilicus. This incision goes down to the peritoneum but not through it. The bladder with its peritoneal covering is grasped with forceps and drawn forward and to one side, while the surgeon makes blunt dissection just outside of the peritoneum (Fig. 1577). This blunt dissection is carried along the side of the bladder until the ureter is brought into view at the base. The ureter is opened, and stone removed or other operation done. After removal of a stone the ureter need not be sutured; but a rubber tissue drain is carried down to the ureteral incision and the rest of the wound closed.

Transvaginal exposure of the ureter is accomplished with the patient in the knee-chest position. An endoscope is introduced into the bladder, and through this a metallic probe is passed into the ureter. A broad retractor

is inserted in the vagina and the perineum lifted backward. The probe in the ureter can now be felt and the ridge caused by it seen. The vagina is incised along this ridge and the ureter may be isolated or incised. This operation may be concluded by division of the ureter at the bladder, closure of the bladder-opening, isolation of the lower end of the ureter by blunt dissection, and then lumbar nephrectomy and ureterectomy.

The ureter may be exposed in the following manner: The patient is placed in the elevated pelvis position as for vaginal operations. The cervix uteri is grasped and drawn down with hooked forceps. A dimple is seen on the anterior vaginal wall opposite the entrance of the ureter into the bladder.

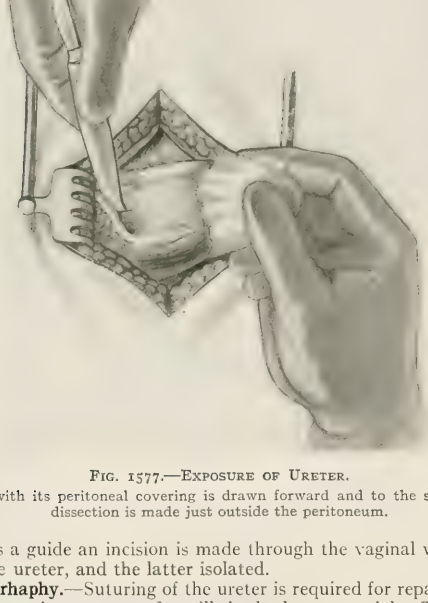


FIG. 1577.—EXPOSURE OF URETER.

The bladder with its peritoneal covering is drawn forward and to the side while blunt dissection is made just outside the peritoneum.

With this as a guide an incision is made through the vaginal wall along the course of the ureter, and the latter isolated.

Ureterorrhaphy.—Suturing of the ureter is required for repair of wounds. Very fine chromic catgut or fine silk is the best material. The operation should follow somewhat the method of intestinal suturing. It is best that the sutures should embrace all of the coats but the mucous membrane. Longitudinal wounds should be closed by one row of sutures close together to prevent leakage. Transverse and oblique wounds should be sutured the same way. Ragged and lacerated wounds or wounds in which simple ureterorrhaphy cannot well be done, may be treated by completing the division and performing anastomosis.

To avoid the danger of stricture, a transverse wound which nearly divides the ureter, may be sutured by the *method of angulation* as applied

to the intestine. A longitudinal incision is added, crossing first. The four corners are cut off and the ureter sutured after folding it upon itself.

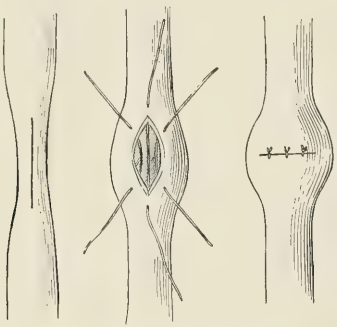


FIG. 1578.—URETEROPLASTY

The narrowed ureter is incised longitudinally and the wound is closed transversely.

Ureteroplasty.—This operation is required for stricture, and consists in making a longitudinal wound into the lumen and suturing it as a transverse wound. On account of tension, fine silk sutures are best (Fig. 1578).

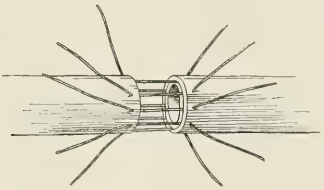


FIG. 1579.—END-TO-END URETERO-URETEROSTOMY.

Uretero-ureteral Anastomosis (Uretero-ureterostomy).—There are many methods of uniting the divided ureter. It is important that the suture material shall be capable of enduring for two weeks, and unless the surgeon knows that his chromic catgut is good for that period fine silk should be used.

FIG. 1580.—END-TO-END URETERO-URETEROSTOMY COMPLETED.

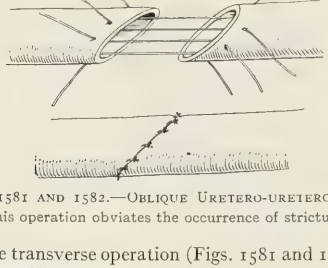
The objection to this operation is that it results in a stricture at the site of anastomosis.

The ends should be dilated before suturing. This may be done with fine forceps.

Transverse end-to-end uretero-ureterostomy requires that the ends to be sutured shall be even and not ragged. The sutures are passed through all

of the coats except the mucosa (Fig. 1579). This operation may be done also with the aid of a support in the form of a ureteral catheter passed upward from the bladder and reaching above the anastomosis (Fig. 1580).

Oblique end-to-end uretero-ureterostomy offers less danger of subsequent stricture than the transverse operation. The two ends are trimmed obliquely



FIGS. 1581 AND 1582.—OBLIQUE URETERO-URETEROSIOMY.
This operation obviates the occurrence of stricture.

and united as in the transverse operation (Figs. 1581 and 1582). Every other suture should be a mattress suture.

End-into-end uretero-ureterostomy by invagination is done after first dilating the distal end, or if adequate dilatation is not possible the distal end should be split longitudinally. One or two traction sutures are placed

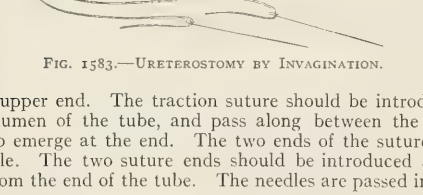


FIG. 1583.—URETEROSTOMY BY INVAGINATION.

through the upper end. The traction suture should be introduced doubly, toward the lumen of the tube, and pass along between the mucosa and muscularis to emerge at the end. The two ends of the suture should each carry a needle. The two suture ends should be introduced about 4 mm. ($\frac{3}{16}$ inch) from the end of the tube. The needles are passed into the lumen

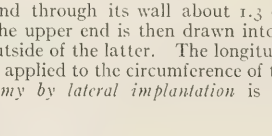


FIG. 1584.—URETEROSTOMY BY INVAGINATION COMPLETED.

of the distal tube and through its wall about 1.3 cm. ($\frac{1}{2}$ inch) from the end (Fig. 1583). The upper end is then drawn into the lower end and the suture tied on the outside of the latter. The longitudinal slit is sewed and a couple of sutures are applied to the circumference of the tubes (Fig. 1584).

Uretero-ureterostomy by lateral implantation is done as follows: The

distal end is dilated and a longitudinal slit is made with a small sharp-pointed knife into its lumen. This incision should be as long as the diameter of the upper segment of the ureter and should leave an interval of a little less than 1.3 cm. (½ inch) between it and the cut end of the lower segment. A traction suture of fine chromic catgut, with two needles, is passed through the upper segment as described for the invagination method. The two needles of this suture are passed into the longitudinal slit of the distal segment caused to penetrate the ureteral wall about 1.3 cm. (½ inch) below the slit side by side a little less than 3 mm. (⅛ inch) apart. A ligature of catgut is then tied tightly around the distal segment midway between the slit and the cut end (Fig. 1585). To reduce the size of the proximal end a longitu-

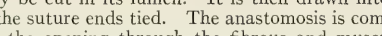


FIG. 1585.—URETERAL ANASTOMOSIS BY LATERAL IMPLANTATION.

dinal notch may be cut in its lumen. It is then drawn into the slit of the distal end and the suture ends tied. The anastomosis is completed by a few sutures around the opening through the fibrous and muscular coats (Fig. 1586). The size of the upper end may be reduced still more if necessary by inserting and tying two or three sutures in its free end. The ends of these may be left long and carried through the lumen of the distal tube and again tied on the outside. This method and end-into-end invagination are the best methods of anastomosis.

Implantation of Ureter.—In cases of division or loss of substance of the ureter by accident or operation, in which uretero-ureteral anastomosis is not possible or not expedient, and in cases of extrophy and other diseases of the

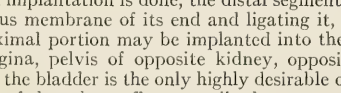


FIG. 1586.—URETERAL ANASTOMOSIS BY LATERAL IMPLANTATION COMPLETED.

bladder, implantation of the upper segment into some other structure is called for. When implantation is done, the distal segment is treated by cauterizing the mucous membrane of its end and ligating it, or by its total removal. The proximal portion may be implanted into the bladder, rectum, colon, cecum, vagina, pelvis of opposite kidney, opposite ureter, or skin. Implantation into the bladder is the only highly desirable operation upon the lower ureter. All of the others offer great disadvantages. When the injury or disease is in the upper end of the ureter, then implantation of the distal segment into the pelvis of the kidney may be done. This and ureterocystostomy are the two desirable operations.

Implantation of the ureter into the bladder (*ureterocystostomy*) may be

intraperitoneal or extraperitoneal. The former affords the better approach, but it should be concluded as an extraperitoneal operation.

Assuming that the lower end of the ureter has been divided or requires resection, a median abdominal section, between the pubes and umbilicus, is done, the patient placed in the lowered head position, and the intestines re-

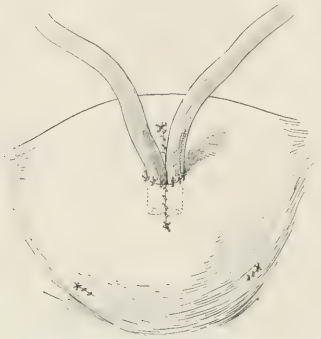
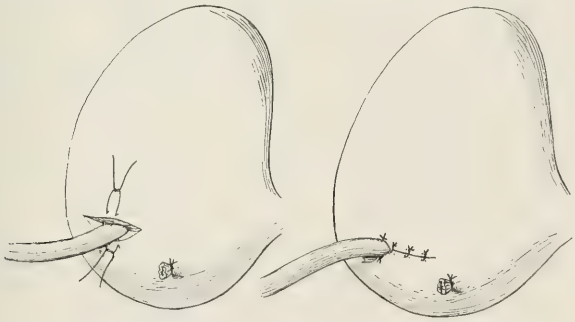


FIG. 1587.—IMPLANTATION OF URETERS IN BLADDER.

tracted upward out of the pelvis. The peritoneum in front of the lower ureter is divided and the ureter is exposed down to the bladder. The distal end of the divided ureter is ligated, its mucosa cauterized, and the stump dropped back into the wound. A point on the wall of the bladder is selected as near the natural entrance of the ureter as possible, which can be reached by the



FIGS. 1588 AND 1589.—IMPLANTATION OF URETER IN BLADDER.

proximal end, and an incision 4 cm. (1½ inches) long made through all its coats except the mucous membrane. This incision should be placed in the natural and easy direction of the ureter (Fig. 1587).

The end of the ureter should be split slightly to insure against stricture. The muscularis of the bladder should be separated from the mucosa for a

short distance along either side of the wound. A small puncture is then made through the mucous membrane at the lower part of the wound and the ureter introduced into the bladder through this opening. The ureter is then sewed to the outer coats of the bladder to prevent its pulling out (Figs. 1588 and 1589).

The ureter should be introduced far enough for its end to be well inside of the mucous membrane. The ureter is then buried between the mucous membrane and the muscular coat by suturing the wound in the latter over it.

If the ureter is so short that the tension is too great, the bladder should be lifted upward by a few sutures placed near the implantation and caught in the most resisting structure above the pelvic ring.

After the implantation is completed the peritoneum should be closed over the ureter by two rows of sutures placed with the view of tightly sealing it. The bladder should be kept free from internal pressure by permanent

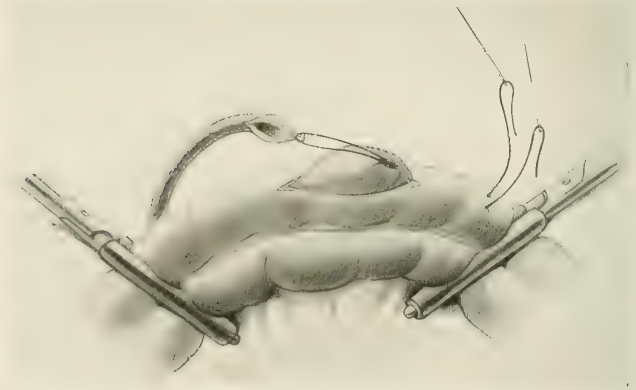


FIG. 1590.—URETEROCOLOSTOMY.
The seromuscularis of the bowel has been incised, the mucosa punctured, and the sutures prepared to draw the ureter into place and fix it.

drainage or by frequent catheterization. If possible posterior drainage of the retroperitoneal space, which was the seat of operation, should be secured. In the female such drainage may be carried out through the vagina.

This operation, like the following one, aims to reproduce the physiological closure of the lower end of the ureter by the lateral internal pressure within the viscus into which it is implanted.

Implantation of ureter into large intestine (ureterocolostomy) may be done when the bladder has been removed, or when ureterocystostomy, ureteroureterostomy, or some better operation cannot be done. The rectum, sigmoid or cecum may be used. The technic is not difficult, but later ascending infection of the kidney from the bowel may be expected. The important feature of these operations is that the ureter should lie for a certain distance in the wall of the intestine so that the intra-intestinal pressure collapses its lumen, and prevents the entrance of intestinal contents.

A median abdominal section is done with the patient in the lowered head position. If the rectum is to be used the sphincter of the anus should first be dilated. The intestines are retracted toward the diaphragm. If the bladder has been removed, both ureters should be exposed and isolated by incising the overlying peritoneum. If both ureters are to be used they should be divided each at the same level.

A longitudinal incision is made in the anterior wall of the rectum, 5 cm. (2 inches) long, passing through all the coats except the mucous membrane, and placed in the middle of the longitudinal band. The muscularis should be dissected back on either side exposing a longitudinal area of mucous membrane. The two ureters should be sutured together at their lower ends for a distance of about 4 cm. (1½ inches) by means of two or three fine chromic catgut sutures through all of the coats except the mucous membrane. Their lumens should be split at the ends for a short distance and a traction suture passed through each wall and tied, its two ends being left long and threaded upon a needle. In the lowermost part of the exposed mucous membrane a

FIG. 1591.—URETEROCOLOSTOMY COMPLETED.

longitudinal cut is made just large enough to receive the two ureters. The needles of the two traction sutures are passed through the opening in the mucous membrane into the bowel, and then caused to penetrate the bowel wall about 1.5 cm. (½ inch) below (Fig. 1590). These two sutures are then used to draw the ureter ends into the bowel, after which they are tied on the peritoneum and cut. The seromuscular wound is then sutured, being lifted up as it is sewed so that the ureters shall be caused to lie between the muscularis and mucosa (Fig. 1591). This is the method devised by R. C. Coffey. It may be applied to one ureter or to both ureters. This same principle is applicable also to implantation of the common bile duct into the bowel.

Instead of the above method, the ureter may simply be split at its end for a distance of 6 mm. (¼ inch), and the end drawn into the lumen of the bowel and fixed so that it hangs free in the lumen for a short distance.

Successful implantations have been made by emptying one ureter into the cecum and the other into the sigmoid. Successful anastomosis with the vermiform appendix has been done. Patients who have had these operations done have survived for varying periods but usually have succumbed soon to ascending infection reaching the kidneys.

Implantation of the ureter or ureters in the rectum may be done when the stump is not too short. It is possible to perform this operation entirely with-

out opening the peritoneum. Under these circumstances it becomes the ideal uretero-enterostomy (Fig. 1592).

Salpingo-ureterostomy is the safest of all the operations whereby the ureter is caused to empty outside of the urinary tract. The anastomosis with a Fallopian tube is done the same as uretero-ureterostomy. Before the operation the patency of the tube and uterine canal should have been tested by the injection of fluid through them. The inconvenience of urine constantly running out through the vagina is very great. The operation should be done as a temporary expedient or it should be followed (1) by anastomosing the cervix with the bladder (uterocystostomy), (2) by closing the vaginal outlet and making a vesicovaginal fistula, or (3) by closing the vaginal outlet and making a urethrovaginal anastomosis. All of these require that the menstrual function shall have stopped naturally or artificially.

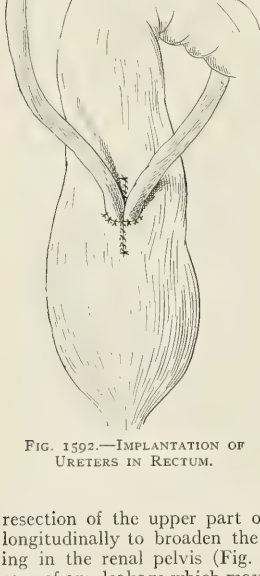


Fig. 1592.—Implantation of Ureters in Rectum.

Implantation into the pelvis of the kidney of the distal end of the severed ureter (ureteropyelostomy) is done for division or resection of the upper part of the ureter. Its upper end should be split longitudinally to broaden the opening, which should be sewed to the opening in the renal pelvis (Fig. 1593). Drainage should be provided to take care of any leakage which may occur.

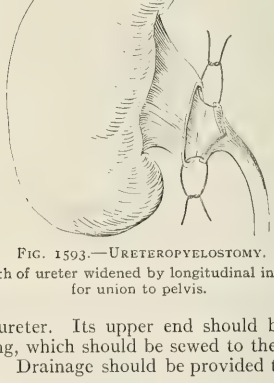


Fig. 1593.—Ureteropyelostomy. Mouth of ureter widened by longitudinal incision for union to pelvis.

Continuous urinary lumbar drainage may be required following nephrotomy, pyelotomy, amputation of the ureter, or cystectomy. It is possible to fit a silver tube, having a flange, into the fistula in such a manner as to keep the clothing dry. Such a tube should be made fast with adhesive plaster. It should be connected by a rubber tube to a receptacle which may be hung at the waist or carried on the inner side of the thigh. B. A. Thomas (Trans. Phila. Acad. Surg., Feb. 7, 1916; Annals of Surg., June, 1916) reported the case of a man who had worn such an apparatus for one and a half years after cystectomy, and was in good health (Fig. 1594). (For Implantation of Ureters with Segment of Bladder, see page 206.)

Implantation in the skin is best done in the loin. When the ureter is

exposed by a lumbar incision its upper end may be sutured to the skin and the rest of the wound closed. If there is any possibility that a later uretero-ureterostomy may be done the distal end also should be attached to the skin so that it may easily be found. When the ureter has been exposed by an anterior abdominal incision, a counter-opening should be made in the loin for implantation.

Implantation of the ureter in other structures follows the general principles already laid down. For implantation into the pelvis of the opposite kidney

FIG. 1504.—LUMBAR URINARY DRAINAGE.

or ureter it must be carried through an opening made in the mesentery, or passed posteriorly to the peritoneum between the soft tissues. The principles described in ureterocystostomy and uretero-ureterostomy are employed. Implantations into the vagina, uterus and urethra have been practised.

SUPRARENAL GLANDS

Tuberculosis.—The general treatment of tuberculosis should be applied. Operations for tuberculosis have been done.

Tumors.—Benign tumors should receive the same treatment as applied in other vital organs. Malignant tumors have been operated upon, but with a high rate of mortality. The glands are not easily accessible. Wide

excision is difficult. In some cases it has been necessary to remove the kidney with the suprarenal. Resection of the vena cava has also been necessary. The best incision is along the lower border of the twelfth rib and thence curving upward to the epigastrium. The operation should be subperitoneal if possible.

THE BLADDER

Anatomy.—The *bladder* is a muscular sac, lined with mucous membrane, situated between the pubes and rectum in the male, and in the female between the pubes in front and the cervix uteri and upper part of the vagina behind. It is covered above by peritoneum.

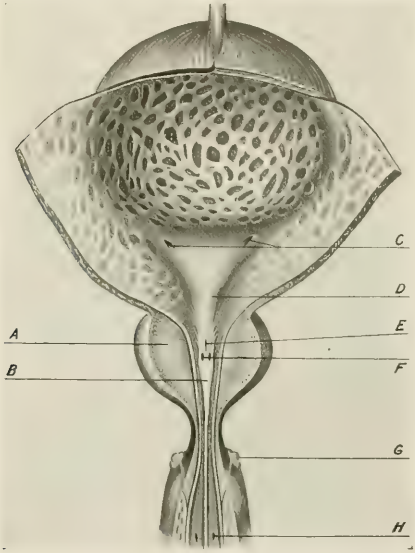


FIG. 1595.—INTERIOR OF URINARY BLADDER AND DEEP URETHRA.

A, Prostate; *B*, verumontanum; *C*, ureteral orifices; *D*, location of internal urethral orifice; *E*, utricle; *F*, orifices of ejaculatory ducts; *G*, Cowper's gland; *H*, orifices of ducts of Cowper's glands.

When distended it rises above to the pubes. When empty its summit rises to about the level of the top of the pubes. The urachus, a fibrous cord, connects its fundus with the umbilicus. The postero-inferior surface below the peritoneum in the male rests upon the rectum, having on either side the seminal vesicles and vasa deferentia. The prostate lies under the bladder and embraces the beginning of the urethra. In front of the bladder and above the pubes is the *prevesical space*, filled with loose connective tissue, above which the peritoneum lies and is lifted up as the bladder fills. In some cases the peritoneum may come down below the level of the upper border of the pubes when the bladder is not full.

The *trigonum* of the bladder is a triangular smooth surface lying at the base of the interior of the bladder, marked at each posterior angle by the ureteral opening and at the anterior angle by the urethral opening. The ureteral openings are situated about 4 cm. (1½ inches) posterior to the urethral orifice, and about 5 cm. (2 inches) apart (Fig. 1595).

The urethral orifice in the bladder in the adult male is about 2 to 2.5 cm. (¾ to 1 inch)

behind the symphysis of the pubes. In children the empty bladder lies higher than in adults. In the adult the base of the bladder is 6.5 or 7.5 cm. (2½ or 3 inches) from the perineum. No vessels of considerable size cross the median line of the bladder either above or below. The average capacity of the adult bladder is about 500 c.c. (1 pint), although it is capable of much greater distention (Fig. 1596). For relations of male bladder, see also Fig. 1494, page 53.

Instruments.—The special instruments required in the treatment of diseases of the bladder are catheters (Fig. 1597), syringes, and cystoscopes. Catheters are made of rubber, woven fabric and rubber, and metal. The self-retaining catheter is useful for continuous drainage (Fig. 1598). Syringes are of the piston type and the simple fountain syringe. Endoscopes and cystoscopes are made in great variety. Sounds are made of metal, and are used for dilating and as guides (Fig. 1599).

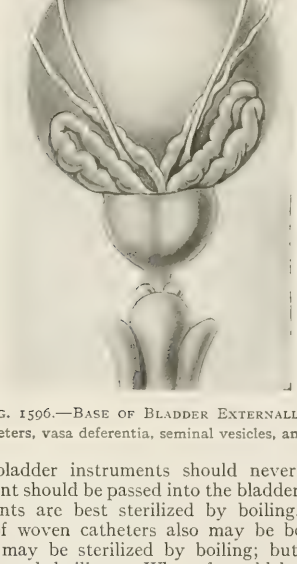


FIG. 1596.—BASE OF BLADDER EXTERNALLY.
Showing ureters, vasa deferentia, seminal vesicles, and prostate.

Sterilization of bladder instruments should never be neglected. No unsterilized instrument should be passed into the bladder. Rubber catheters and metal instruments are best sterilized by boiling. Certain forms of the better quality of woven catheters also may be boiled. Filiform and whale-bone bougies may be sterilized by boiling; but these, like rubber, deteriorate after several boilings. When formaldehyd gas is used the instrument should be washed in sterile water to remove the irritating formalin before introducing it into the bladder.

Lubrication of instruments to be passed through the urethra into the bladder should be done with some soluble substance. Vaselin is highly objectionable, because it is removed with difficulty, it smears the mucous membrane of the urethra with a coat that prevents the action of local anesthetics, and it may act as a nucleus for the formation of stone in the bladder. Sterilized olive oil has all of the objections but the last. The best

lubricant is made with gum acacia as a base. The following formula is recommended by Casper:

Oxycyanid of mercury	0.246	(3½ grains)
Glycerin	20.0	(5 drams)
Gum tragacanth	3.0	(46 grains)
Water	100.0	(3 ounces)

This irritates some urethras, and should contain about half the amount of mercury.

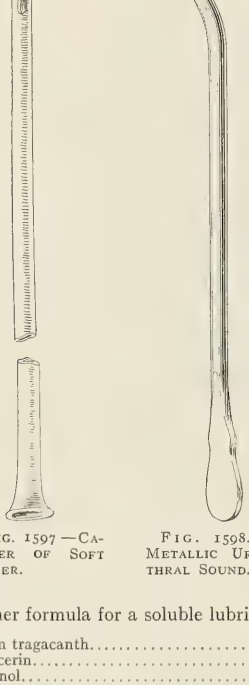


FIG. 1597.—CATHETER OF SOFT RUBBER.

FIG. 1598.—METALLIC URETHRAL SOUND.

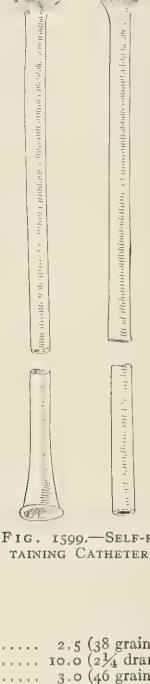


FIG. 1599.—SELF-RETAINING CATHETERS.

Another formula for a soluble lubricant is:

Gum tragacanth	2.5	(38 grains)
Glycerin	10.0	(2¼ drams)
Phenol	3.0	(46 grains)
Water	100.0	(3 ounces)

A good quality of glycerin, to which is added 1 per cent. of boric acid, is a good lubricant, excepting that it may irritate a very sensitive urethra. Irish moss jelly is also used instead of gum tragacanth. The French use a lubricant composed of equal parts of glycerin, soap and water.

The introduction of sounds and catheters should be with the utmost gentleness. Not force but delicacy of manipulation is the key to success.

The patient should lie on his back in a relaxed and comfortable position. The pelvis should not sink into a soft bed. The surgeon, holding the instrument in the right hand, should stand on the left side of the patient. Sterile cloths should cover the whole field except the penis. The glans penis should be exposed and cleansed, and some lubricant placed at the meatus. The instrument should be smeared with lubricant applied with a bit of gauze or the gloved hand.

The surgeon grasps the penis at the corona, the prepuce being retracted, and makes gentle traction forward to eradicate the urethral folds, and opens the meatus. A soft catheter glides easily through the urethra into the bladder by being gently pushed along. Its entrance into the bladder is announced by the flow of urine from its end, or, if the bladder is empty of urine, by the appearance of a bubble.

In passing a curved metal catheter or sound, more skill is required. Some anatomical knowledge must be brought to bear to cause the instrument

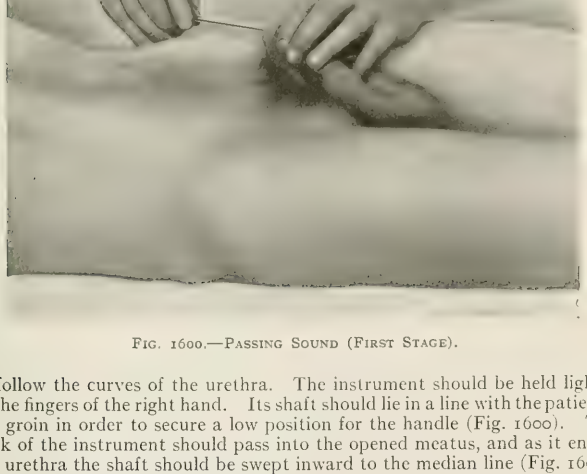


FIG. 1600.—PASSING SOUND (FIRST STAGE).

to follow the curves of the urethra. The instrument should be held lightly in the fingers of the right hand. Its shaft should lie in a line with the patient's left groin in order to secure a low position for the handle (Fig. 1600). The beak of the instrument should pass into the opened meatus, and as it enters the urethra the shaft should be swept inward to the median line (Fig. 1601). When the beak has traversed the penile portion of the urethra, it enters the fixed portion, and should now be caused to follow the urethral curve. The shaft of the instrument should be lifted forward. In making this motion the handle should describe the arc of a circle, the center of which is at the pubes. At the same time the beak should not remain fixed, but should move in the opposite direction, swinging backward beneath the pubes; and the whole instrument should move onward through the urethra toward the bladder. Just in front of the triangular ligament the urethra widens into a loose pouch, and the beak may impinge against the front of the ligament. To prevent this, it should be lifted forward and caused to approach more closely the

under surface of the pubic arch; or the fingers of the left hand should be applied to the perineum and caused to lift the instrument over the obstruc-

FIG. 1601.—PASSING SOUND (SECOND STAGE).

FIG. 1602.—PASSING SOUND (THIRD STAGE).

tion (Fig. 1602). As the beak follows the urethra through the triangular ligament, it enters the membranous urethra. At this point the handle should

be depressed between the thighs, causing the beak to pass upward through the prostatic urethra into the bladder (Fig. 1603).

When the bladder is entered, the instrument may be rotated or swept freely about. If it is introduced for the removal of urine it need only be held lightly until the flow has ceased. In withdrawing the instrument, the steps of introduction are reversed.

The smaller the sound the greater the danger of puncturing the urethra. Sounds smaller than No. 20 French should not be entrusted to any but experienced hands. The largest instrument that will comfortably slip in should be employed.

Cystoscopy.—Cystoscopy is employed in surgical treatment for catheterizing the ureters and for performing operations within the bladder. Many forms of instrument are made. The straight hollow tube (endoscope) is the most simple instrument (Fig. 1604). Its field of usefulness is limited. The

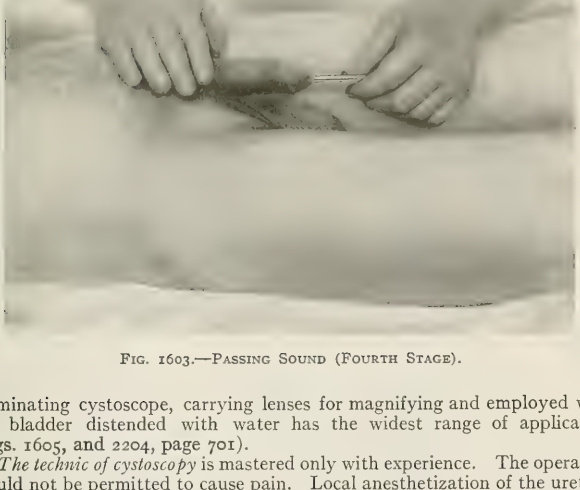


FIG. 1603.—PASSING SOUND (FOURTH STAGE).

illuminating cystoscope, carrying lenses for magnifying and employed with the bladder distended with water has the widest range of application (Figs. 1605, and 2204, page 701).

The technic of cystoscopy is mastered only with experience. The operation should not be permitted to cause pain. Local anesthetization of the urethra should be secured in most cases. In extremely sensitive individuals general anesthesia is necessary. Some patients tolerate the operation without narcotics. For local anesthetic purposes 1.2 c.c. (20 minims) of a 4 per cent. solution of cocain is injected with a deep urethral syringe into the posterior urethra. Some cystoscopists prefer to deposit a tablet of dry anesthetic with a tablet depositor.

The operation should be preceded by washing out the bladder through a soft catheter until urine, mucus, pus, blood or any other material which might obscure the vision, has been removed. After the cleansing, the anesthetic is applied, and the bladder distended with clear salt solution. Enough

fluid should be introduced to distend the bladder to give working room for the cystoscope. From 120 to 300 c.c. (4 to 10 ounces) should be used.

The patient should lie upon his back, with the pelvis raised and resting at the foot of the table. All aseptic precautions should be observed. The cystoscope, having been tested, is introduced as a sound, and is then connected with the electric current. The operator takes his seat between the patient's flexed thighs and applies his eye to the instrument.

Catheterization of the ureters is best accomplished by the double catheterizing cystoscope, which provides for the catheterization of each ureter at a single operation. The ureteral openings are recognized as small slits or dimples, often at the apex of a slight elevation of mucous membrane. The urine is seen issuing from the opening at short intervals, making a character-

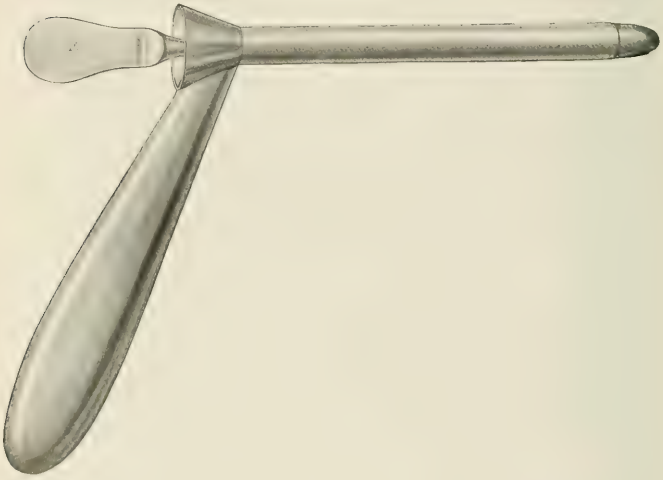


FIG. 1604.—ENDOSCOPE. (*Kelly.*)

istic swirl in the clear fluid. If the urine has been colored by the previous administration of methylene-blue or indigo-carmin solution, it is even more clearly seen. The ureteral opening being recognized the tip of the catheter is rotated into it and pushed into the canal as far as necessary (Fig. 1606).

Catheterization of the ureter *in the female* is easier than in the male. A shorter instrument is used, and air distention of the bladder may be substituted for fluid. Or by placing the patient in the knee-chest position and introducing a simple bladder endoscope air rushes in and permits direct vision catheterization of the ureters with no further illumination than a forehead lamp.

Instead of water, *air distention* may be used in the male, and is best with the operating cystoscope. It is accomplished by connecting the cystoscope with an air bulb for pumping in air. This is necessary in cystoscopic operations in the bladder, for with air distention a flow of blood may be caused to

gravitate out of the way by placing the patient in the extreme elevated-pelvis position. Air distention is more painful than water.

For **renal lavage,** the ureteral catheter is passed to the renal pelvis, and the cystoscope removed. The lavage may then be carried out deliberately

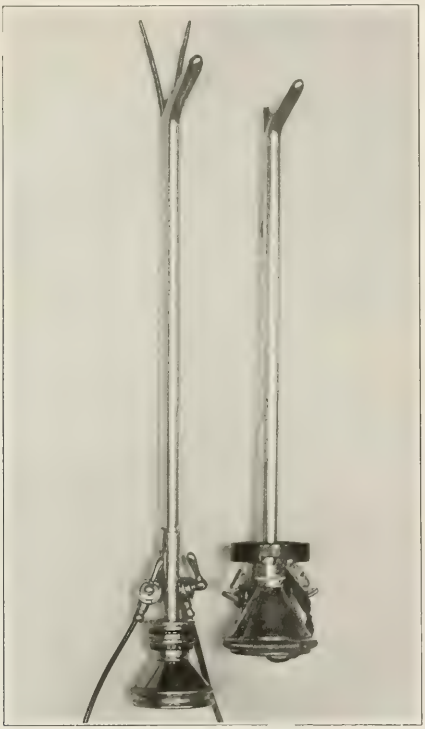


FIG. 1605.—CATHETERIZING CYSTOSCOPE, SHOWING CATHETERS EMERGING. (*From Pilcher's Cystoscopy.*)

and painlessly. Rarely will it be advisable to leave a catheter in the pelvis for permanent drainage (Fig. 1607).

The reader is referred to the special works on cystoscopy for the more minute details of these operations.[1]

[1] P. M. Pilcher's "Practical Cystoscopy" is recommended.

Injuries of the Bladder.—*Contusions* are rare, and require only symptomatic treatment such as is necessary for temporary atony or hemorrhage.

Wounds and rupture of the bladder belong to the most serious of surgical injuries. Little can be said for prophylaxis except that an individual before

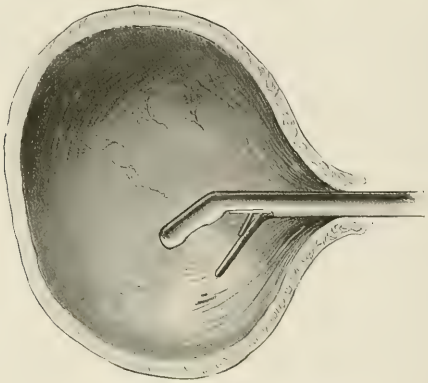


FIG. 1606.—CATHETERIZATION OF URETER.
The catheter is seen about to enter the ureter.

exposing himself to the dangers of physical injury does well to empty the bladder. Upon making a diagnosis, suprapubic cystotomy should be done.

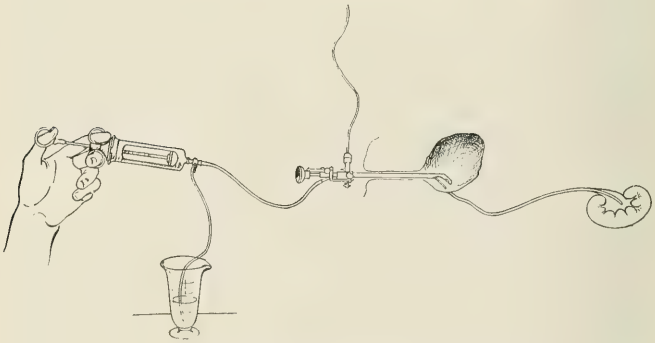


FIG. 1607.—IRRIGATION OF THE PELVIS OF THE KIDNEY.
Showing ureteral catheter in place in the renal pelvis and syringe throwing fluid into the pelvis. (*After P. M. Pilcher.*)

If the rupture involves the peritoneum the abdomen should be opened. Immediate operation is called for in all cases. When there is doubt as to the diagnosis, operation is indicated.

Intraperitoneal rupture of the bladder constitutes fully 85 per cent. of cases. A low median abdominal section is indicated. A rupture being found, the urine should be sponged out of the abdomen, ragged edges should be trimmed, and the bladder wound closed by sutures. The suture should be a continuous—occasionally interrupted—suture of chromic catgut, embracing all but the mucous coat. To make the wound especially secure, a second seromuscular suture should be added to this. So far as the peritoneal surface is concerned, it should be treated by the rules laid down for peritoneal injuries. The bladder should be relieved of tension by providing continuous drainage. This may be accomplished by placing a tube in the bladder, or by fixing a permanent catheter in the urethra (see Drainage of the Bladder, page 221). Such drainage should be continued for ten days, and with the utmost vigilance to see that no stoppage of the drain occurs. In addition to keeping the walls of the bladder thus relaxed, the urine should be maintained in a non-irritating state. A urinary antiseptic should be administered.

Extraperitoneal rupture of the bladder is usually found in the region of the trigone; less often it occurs in the anterior wall; sometimes in the lateral walls, or near the urethra. As the extravasated urine tends to gravitate, it finds its way to the region behind the prostate. After suprapubic recognition of the injury, perineal drainage of the subvesical space is indicated. This drainage should reach the connective-tissue spaces in the region of the base of the bladder.

Inflammation of the Bladder (Cystitis).—The prophylaxis of cystitis is most important. The better the general physical resistance, the less danger is there of cystitis. Cleanliness in passing instruments into the bladder is essential; but if catheterization must long be continued, cystitis should be expected sooner or later because of the difficulty of freeing the urethra of bacteria which naturally reside in it. Sanitary and moral prophylaxis, applied to the sexual relations, can be of much help in diminishing the frequency of gonorrhea which is a potent factor in the causation of cystitis.

When conditions exist which predispose to cystitis especial care of the general health, regulation of the bowels, the ingestion of abundance of fluids, and proper rest are important.

Internally administered urinary antiseptics (drugs which cause an antiseptic substance to be excreted in the urine) are of great value. Among these may be mentioned urotropin, helmitol and formin, all of which are essentially the same as hexamethylenamin of the pharmacopeia. Others are salol, benzoic acid and benzoate of soda (see page 141).

The diet should be simple and food should be taken in moderation. Alcohol, tobacco, and meat tend to aggravate the irritation. Milk, cereals, vegetables, bread and butter should constitute the chief diet.

Acute cystitis, with bladder irritability and pain, should be treated by rest in bed and measures to render the urine unirritating. Hot sitz-baths or hot stupes to the suprapubic and perineal regions are of service. Heat may be applied in the rectum by means of an irrigating stream escaping through an exit tube. For keeping the rectum slightly distended with hot water a double-current catheter is useful; it may be arranged so that the outflow is slightly retarded. Relief may be secured in some cases by immersing the patient in a bath of hot water up to his waist and allowing urination under the water.

Vesical tenesmus when severe, may be relieved by a rectal suppository of morphin and atropin, or extract of hyoscyamus.

Usually irrigation of the bladder is best deferred until the severely acute stage has yielded to the above measures. If the irritation or local congestion

causes inability to urinate, the disease is aggravated by distention. In such cases a small, soft rubber catheter should be passed to draw off the urine.

Irrigation should be employed in cases which do not subside and in those which require catheterization for retention. At first mild solutions should be used. The fluid should be warm 38°C., (100°F.). Quinin bisulphate is the most satisfactory. It is more antiseptic than boric acid. Used in a strength of 1 : 2000 it is not irritating. Boric acid solution is most used. Normal salt solution is the least irritating. Fluidextract of hydrastis may be combined with either. As the patient becomes accustomed to irrigation, stronger solutions may be used. Bichlorid of mercury or oxycyanate of mercury (1 : 10,000 to 1 : 5000), nitrate of silver (1 : 3000 to 1 : 300), permanganate of potash (1 : 5000 to 1 : 1000), or phenol (1 : 1000 to 1 : 500) may be employed.

It is best to irrigate, if possible, without introducing an instrument into the bladder. The patient should lie upon the back with muscles relaxed. The warmed fluid should be placed in a fountain syringe, elevated 60 or 90 cm. (2 or 3 feet). The end of the tube should be provided with a conical tip such as possessed by the Janet syringe, which is capable of stopping the urethral meatus. The fluid is allowed to flow into the urethra, and if the patient can be induced to relax his muscular system, the fluid will pass the cut-off muscle and enter the bladder. As much as 120 to 240 c.c. (4 to 8 ounces) will be tolerated before the patient complains. The flow should then be stopped and the patient caused to void the fluid. If the bladder will hold only 60 c.c. (2 ounces) without pain, no more should be injected; but repeated injections should be made until the fluid returns clear.

The patient should not be caused pain. If the sphincter muscles do not relax to permit the inflow of fluid, 1 or 1.3 c.c. (15 or 20 minims) of a 2 per cent. solution of cocain should be injected into the deep urethra. This solution should be injected into the anterior urethra and forced back by injection of air. After from two to five minutes the sphincter will be found relaxed, and fluid can be passed into the bladder.

In mixed infection, cystitis associated with *Bacillus coli*, *B. proteus*, streptococci and staphylococci, good results are secured by injecting into the bladder a suspension of pure culture of *Bacillus Bulgaricus*. After washing out the bladder with sterile, nonantiseptic solution, plain water or salt solution, 20 c.c. of the suspension of Bulgarian bacillus in pure culture are injected into the bladder and left there. This treatment should be given daily. It is capable of keeping the urine acid and preventing phosphatic deposits. The internal administration of acid sodium phosphate should accompany the treatment.

In acute cystitis of *gonorrheal* origin, it is best to employ irrigation at once and not defer the treatment until the more acute symptoms have subsided. (The surgeon should not confuse deep urethral irritation with cystitis.) Nitrate of silver solution is of especial efficacy in these cases.

Chronic cystitis does not necessarily require confinement in bed. The dietary and hygienic measures should be insisted upon. The urinary antiseptics should be given a trial. If they fail, the balsams which are excreted by the kidneys may be employed. Fluid extract of kava kava in 4 c.c. (1 dram) doses, may be given every four hours.

Irrigation of the bladder should be practised if there is much pus in the urine. Something stronger than boric solution is desirable. Bichlorid of mercury and permanganate of potash are of value. An effective solution is composed of tincture of iodin, 1 to 3 parts, iodid of potassium, 1 part, and water 300 parts. Daily irrigation may be practised.

Silver nitrate is most effective in chronic cystitis. It should be used at first in very weak solution. It should not be employed in conjunction with

other antiseptics which may neutralize it. A solution of the strength of 1 : 10,000 should be used at first. The strength may be increased gradually up to 1 : 5,000 if the patient bears it well. The bladder should be emptied of urine and then filled with the silver solution. The solution should be retained until the impulse to empty the bladder becomes strong. The treatment should be repeated every second, third, or fourth day and the strength of the solution gradually increased.

Some cases do not tolerate silver or are not benefited by it. An antiseptic astringent may be used in these. The solution of zinc sulphate, phenol, and alum, 1 part of each to 1000 or 500 parts of water is much used.

Enlarged prostate, stricture of the urethra, pyelitis or other complication may be found responsible for keeping awake a chronic cystitis. Such conditions should always be looked for in intractable cases. Chronic cystitis, not yielding to the ordinary measures, may be cured by continuous irrigation or drainage. Continuous irrigation may be secured by fixing in the urethra a double-current rubber catheter, and causing a constant flow of aseptic or antiseptic fluid to pass through the bladder.

Continuous drainage of the bladder may be employed in intractable cases. This is accomplished by perineal cystotomy and the placing of a tube in the opening. Vaginal drainage is employed in the female. In some cases adequate drainage may be secured by means of a self-retaining catheter placed in the urethra. In *membranous* and *gangrenous cystitis*, perineal drainage is especially indicated.

Tuberculosis of the bladder (tuberculous cystitis) should receive the general constitutional treatment which should be given to all forms of tuberculosis (see Tuberculosis, Vol. I, page 276). This is especially important in tuberculosis of the bladder because it is almost invariably associated with tuberculosis in other organs. The constitutional and hygienic treatment is the important thing; and, although local treatment is of importance, it is of minor moment when compared with the general treatment. The internal administration of creosote and guaiacol would be of value did it not disturb digestion.

Tuberculosis of the kidney is so commonly present in this disease that treatment should be aimed especially at the renal lesion (see Tuberculosis of the Kidney, page 149). The removal of a tuberculous kidney is the most expeditious means for curing tuberculous cystitis; but inasmuch as the other kidney may be tuberculous also, recurrence of the bladder lesion can receive but one such treatment.

Local treatment with 6 per cent. phenol is as effective as any medication. If the tuberculous kidney has been removed this treatment proves most useful. The bladder should be washed out every other day at first with sterile water and then injected with 40 or 60 c.c. of fresh warm phenol solution. This should remain in for two minutes and then be allowed to come away. At first the fluid returns turbid. The injections should continue until the fluid returns nearly clear. The intervals between treatments may be lengthened as improvement progresses. Six to eight weeks of this treatment should cure most cases if there is no other focus of infection and if the infection has not penetrated deeper than the mucous membrane. Local treatment with other drugs may do more harm than good. When the infection is a mixed one, local treatment is of especial benefit. The injection into the emptied bladder of iodoform, mixed with ten times the amount of sterilized olive oil, in quantity up to 15 c.c. (½ ounce) has proved effective. The oil should be allowed to remain in the bladder as long as it will. Silver nitrate solution has been much used, but its value still is in question. No

local treatment is worth while that interferes with the general health. Painful and depressing measures are contraindicated. If any treatment threatens to be painful it should be preceded by injection of cocain into the bladder, and a suppository of opium in the rectum.

Operative treatment applied to the bladder has little to offer. I believe that I have seen benefit from continuous irrigation through a suprapubic opening. Bransford Lewis has called attention to benefit which he has observed following air inflation of the bladder. This, combined with iodoform injections, is capable of producing much amelioration of symptoms.

Curettage of the ulcerated areas and the application of 1:1000 bichlorid of mercury has been practised. Some surgeons advise removal of the

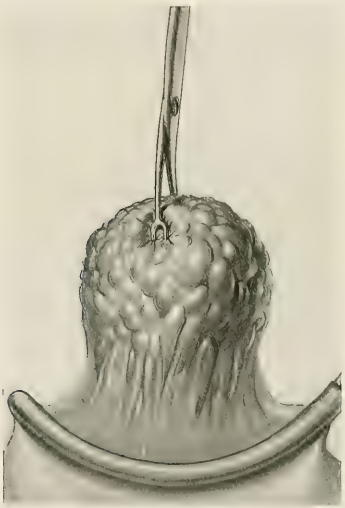


FIG. 1608.—REMOVAL OF TUMOR OF BLADDER.
The tumor is grasped with tenaculum forceps and the base clamped with curved forceps.

tuberculous kidney, and, when both are affected, removal of the worst. While many cases have benefited by this treatment, it is very doubtful if it is a good rule to lay down as an approved line of surgical action.

Exclusion of the urine from the diseased bladder by pyelostomy or ureteral implantation, insuring rest and freedom from irritation for the bladder, has given some good results. *Chronic infiltrating ulceration of the bladder,* in which all of the coats are infiltrated, minute superficial ulcers are present, and the symptoms are severe, is cured by excision of the infiltrated area. On account of the sterile state of the urine and the absence of discoverable bacteria in the bladder wall, healing in these cases seems to be prompt and the cure complete.

Tumors of the Bladder.—Whether benign or malignant, the best treatment of tumors of the bladder is complete extirpation. The differentiation

between benign and malignant epithelial tumors should not be strictly made as there is a great proneness for the former to become malignant. This particularly applies to the pedunculated and papillomatous growths. The

FIG. 1609.—SUTURING WOUND OF BLADDER FROM THE INSIDE.

earlier they are removed the better. Tumors which are obviously malignant from the beginning should be removed with the neighboring bladder wall.

Most varieties of benign growth are best removed by excising an elliptic area of mucous membrane bearing the tumor. This is done preferably

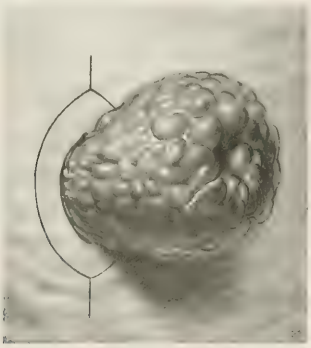


FIG. 1610.—EXCISION OF TUMOR OF BLADDER AT URETERAL ORIFICE.

through a suprapubic cystotomy opening. The growth may be lifted forward, drawing up with it the bladder wall. Even in the case of sessile tumors something of a pedicle may thus be formed (Fig. 1608). After

cutting away the tumor, the clamp may be removed and the wound sutured or the sutures may be applied external to the clamp and then tightened after its removal. Or a purse-string suture may be introduced around the base of the tumor, a clamp applied, the tumor cut away, the clamp removed, and the suture tied (Fig. 1609).

If the tumor involves the orifice of the ureter, the whole thickness of the bladder wall should be involved in the elliptic excision (Fig. 1610). The ureteral attachment and the lower end of the ureter should be drawn forward into the bladder, and the ureter caught by sutures and amputated a safe distance above the tumor (Fig. 1611). It is then fixed to the bladder opening, and the rest of the wound closed (Fig. 1612). This is the technic described by Greene and Brooks.

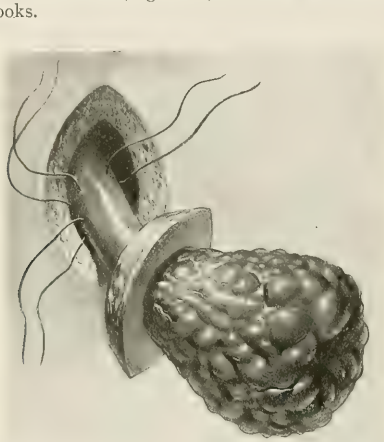


FIG. 1611.—EXCISION OF TUMOR OF BLADDER AT URETERAL ORIFICE.
The tumor, ellipse of bladder wall, and ureter are drawn forward; sutures are passed before the ureter is divided.

The most common tumor of the bladder is *papilloma*. No method of treatment has given better good results than intravesical application of the high-frequency electric spark, called fulguration (see page 699).

Other tumors, infiltrating the bladder wall, require excision of the whole thickness of the bladder, and suture of the wound. Whenever resections of the bladder wall allow sutures to be placed externally this should be done, the sutures being so applied as not to penetrate the mucous membrane.

Malignant tumors require wide resection. When the bladder wall, involving the ureters, must be removed, the ureters should be reimplanted in the bladder or in some other part (see Implantation of Ureter, page 176). In some cases *total extirpation of the bladder* may be undertaken. This operation (*cystectomy*) is indicated in malignancy, encroaching upon the whole of the trigonum and spread out over so much of the bladder as to make partial resection impracticable; in multiple papillomata scattered widely throughout the bladder; and in extensive involvement of the bladder in growths of adjacent organs. The operation, if possible, should be done external to the

peritoneum, through a liberal transverse or vertical suprapubic incision. When the peritoneum is not involved in the growth it can be stripped from the bladder by blunt dissection. After cystectomy, the ureters may be implanted in some other structure or a new bladder may be made (see page 226).

In many cases adequate room is not secured by the extraperitoneal method, and a *transperitoneal operation* for bladder tumor will be found best. In experienced hands this operation has a wider range of application than the extraperitoneal operations. In operating for papilloma, it should be borne in mind that, while the growth may be radically removed, the cells which become loosened by manipulation and implanted in the wound give rise to recurrences which rapidly tend to become malignant.

For *intravesical operations*, some admirable cystoscopes have been devised. That of H. Meyer is effective for removing pedunculated papillomata. For papilloma the high-frequency current (unipolar of Oudin) applied by an electrode passed through the catheterizing cystoscope, experience so far has shown, gives results quite as good as bloody excision.

In *inoperable tumors* of the bladder relief from distressing symptoms may be secured by perineal or suprapubic cystostomy.

To *control hemorrhage* in such tumors the injection into the bladder of a 1 per cent. solution of creolin is often effective (see Hematuria, page 209).

FIG. 1612.—EXCISION OF TUMOR OF BLADDER AT URETERAL ORIFICE.

Operation completed by sewing ureter in upper angle and closing the rest of the wound.

Stone in the Bladder.—The *prevention of stone* is given too little consideration. Uric acid and calcium oxalate stones may be prevented by adequate exercise, good digestion, and oxidation. Excess of nitrogenous food, and of vegetable foods containing much acid should be avoided. The conditions which predispose to gout and rheumatism should be guarded against.

Cystitis should be cured, if for no other reason, than to prevent stone. Alkaline urine sooner or later throws down crystals of the alkaline salts, and enlarged prostate or other cause of retention unless cured is apt to result in stone. Cystin, appearing in the urine, can be eliminated by the administration of carbonate of ammonia.

Persons having urine of high specific gravity, and those with uric acid crystals should imbibe water freely. For such purposes it is best to take water between meals. Piperazin and the salts of potash seem to be effective in preventing the deposit of uric acid crystals. Nitric and hydrochloric acids administered internally diminish the amount of undissolved phosphates in the urine.

When the alkaline reaction of the urine is due to bacterial infection of the urinary tract, the exhibition of urinary antiseptics may be used to correct it.

The internal remedies which are credited with the power to dissolve stones are not wholly without merit, for it is possible, by changing the specific gravity and the reaction of urine, to cause a swelling, bursting, or dissolution of some of the layers of stone which may result at least in breaking it into smaller fragments. Such occurrences have been noted; although too much is made of this possibility by the proprietary exploiters of so-called stone-

dissolving remedies. The possibilities of this line of treatment are not sufficient to justify the surgeon in placing dependence upon it.

Fine gravel, sand, and small stones may be washed out or passed unconsciously by the patient. Small stones are sometimes caught in the eye of a catheter and removed.

Operative treatment of stone in the bladder is one of the oldest of surgical operations. The old operation consisted in cutting open the bladder and removing the stone. Cystotomy for this purpose has been performed through the perineum, in the suprapubic space, through the vagina, and rectum. The modern operation consists in crushing the stone and removing the fragments (litholapaxy) without a cutting operation.

Fig. 1613.—Lithotrite.

In skillful hands the danger of litholapaxy is less than that of cystotomy. The hazard of either operation is least among children under fourteen, and greatest among men of fifty and over. The genito-urinary specialist favors litholapaxy; the general surgeon is prone to employ cystotomy. The patient will do best to employ the former.

Skillfully performed litholapaxy need inflict no damage. In cases of enlarged prostate the operation may cause congestion enough to make catheterization necessary, but when this is the case it may be assumed that treatment for obstruction also should have been undertaken or would soon have been required. Litholapaxy does not endanger the seminal ducts nor is it so apt to cause incontinence as is perineal cystotomy. The latter operation may be followed by fistula.

Suprapubic cystotomy has superseded the perineal operation; but its mortality is still higher than that of litholapaxy, and it may be followed by fistula. When fistula persists, it is usually the case that the patient should have been treated for urinary obstruction.

The *recurrence of stone* is possible after any operation. It is to be prevented by removing all of the calcareous matter, by insuring complete emptying of the bladder, and by the application of the principles described for the prevention of stone.

The *choice of operation* should be influenced by the preference of the surgeon, and should be that with which the surgeon has the greatest familiarity and skill. In general, litholapaxy is to be preferred in all cases in which the urethra will admit the instruments. If it is found that the stone is too large to be grasped by the lithotrite or too hard to be crushed, cystotomy should be done. Cases of stone with a foreign-body nucleus which will not crush or pass through the instrument; cases of stone located in a pouch and which cannot be grasped; and cases in which the bladder cannot be entered because of enlarged prostate, false passage, or other impediment, require treatment by cystotomy. The suprapubic operation is usually to be preferred to the perineal operation. A stone impacted in the prostate is best reached by the perineal route.

A stone, existing in a bladder obstructed by enlarged prostate, should be removed at the operation for the prostatic obstruction. Suprapubic cystotomy is the operation of choice for encysted stone .

Litholapaxy consists in crushing the stone by an instrument in the bladder and evacuating the fragments. *Lithotrity* (the crushing of the stone) is

accomplished by the *lithotrite*, an instrument invented in the early part of the nineteenth century, perfected by Bigelow, of Boston, and later modified by other surgeons (Fig. 1613). The instrument consists of two blades, terminating in jaws, capable of being screwed together, and taking the form of a curved urethral sound. The instrument, as modified by Chismore, has a catheter in the inner blade through which a stream of water can be thrown into the bladder or sucked out while the lithotrite is in place. This often permits sucking the stone between the jaws, while with the other instruments it was necessary to feel about in the bladder until the stone could be engaged. It also permits regulating the amount of fluid in the bladder during the operation and evacuating particles as the operation proceeds.

The *evacuator*, employed in litholapaxy, is still that devised by Bigelow (Fig. 1614). It consists of a metallic catheter tube, a heavy elastic bulb, and a receptacle for fragments. Either a straight or curved catheter may be used. The former is better as it offers the least resistance to the escape of fragments, but the latter may be used in cases in which the introduction of the

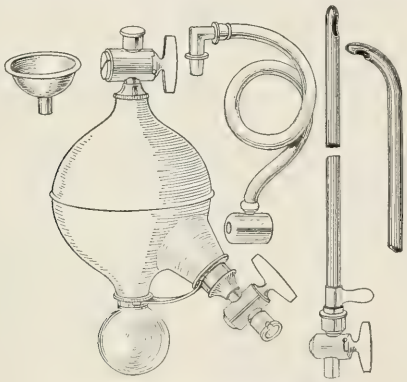


FIG. 1614.—EVACUATOR FOR LITHOLOPAXY.

straight tube is difficult. A rubber tube connects the suction bulb at its summit with a vessel of fluid. At the bottom of the bulb is a glass receptacle into which the fragments gravitate as they are sucked out of the bladder.

The *operation* is best done under cocainization of the deep urethra and bladder. Most operators prefer general anesthesia. The patient should lie supine at full length upon a firm table. The rectum should be empty. For local anesthetization, 45 to 90 c.c. (1½ to 3 ounces) of a warm 1 per cent. solution of cocain is injected into the bladder through the searcher or a catheter. Anesthetization is secured in about five minutes. If the instrument of Chismore is used, it should be well lubricated with 10 per cent. boric ointment, made with lanolin. This should be thoroughly worked in between the shafts of the two blades in order to make the joint water-tight. If this is not done water will escape between the blades when the bulb is compressed and air will rush into the bladder when the bulb expands, and failure is invited. The position and size of the stone should have been determined by a searcher; usually it lies just back of the prostate.

The lithotrite should be introduced carefully so as not to excite spasm. It should be passed as a sound (see Sounds, page 184). The urethra should have been injected with aseptic lubricant. The instrument should be carried until its tip is just beyond the stone; the jaws should then be separated

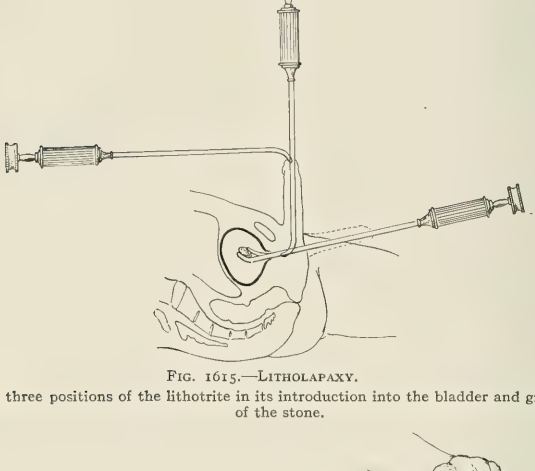


FIG. 1615.—LITHOLAPAXY.
Showing three positions of the lithotrite in its introduction into the bladder and grasping of the stone.

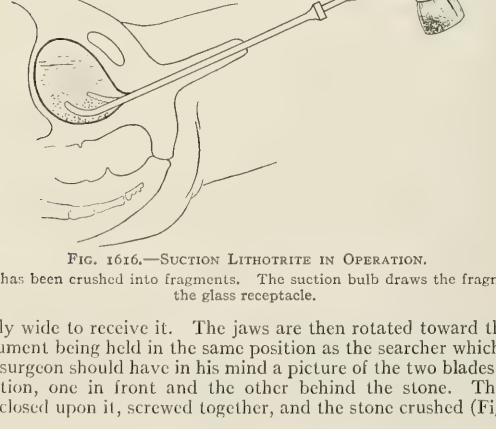


FIG. 1616.—SUCTION LITHOTRITE IN OPERATION.
The stone has been crushed into fragments. The suction bulb draws the fragments into the glass receptacle.

sufficiently wide to receive it. The jaws are then rotated toward the stone, the instrument being held in the same position as the searcher which located it. The surgeon should have in his mind a picture of the two blades rotating into position, one in front and the other behind the stone. The blades are then closed upon it, screwed together, and the stone crushed (Fig. 1615).

If the stone is not grasped at the first attempt, another trial should be made. If this fails, the bladder may be lifted up with the convexity of the instrument, the latter being rotated and the handle depressed. The aspirator is then attached to the instrument and 30 or 60 c.c. (1 or 2 ounces) of fluid injected. Then as the aspirator bulb is relaxed and the fluid sucked out the jaws are caused to descend upon the stone. Various positions may be tried. When the stone is grasped it should be moved about to ascertain that the bladder wall is not included in the bite. The crushing of the fragments should continue until the last fragment has been reduced to a size sufficiently small to pass out through the catheter (Fig. 1616).

In using the Bigelow apparatus, with lithotrite and aspirator separate, from 120 to 180 c.c. (4 to 6 ounces) of sterile salt solution should be injected

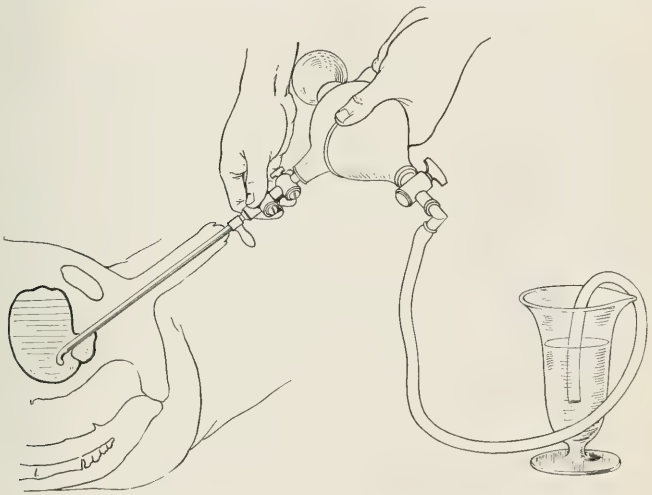


FIG. 1617.—EVACUATOR OF BIGELOW IN ACTION.
The instrument is shown washing out a pocket behind the prostate.

into the bladder. The stone should be crushed, and then fragment after fragment crushed, if necessary. After the stone has been reduced to small particles, the jaws of the lithotrite should be screwed together and the instrument removed.

The evacuator then is brought into play. The straight tube is always to be preferred. The curved tube should be used as a last choice when the other cannot be introduced. None but a surgeon skilled in the passage of urethral instruments should attempt the operation. The tip of the tube should be elevated a little above the bladder floor at first so that as pumping is begun too much débris is not sucked in at once. As the bulb is compressed the fragments are sent swirling about. As the bulb is relaxed and allowed to expand they are sucked into it, and then gravitate into the glass receptacle. As the fragments become fewer an interval of time may elapse between expulsion and suction in order to permit them to settle to the base of the

bladder, then by placing the end of the tube at the base, suction may be expected to remove the last of the fragments. The operation should continue until the fluid returns clear. The glass receptacle should be emptied as it fills with stones. When more fluid is needed, it should be pumped in through the tube at the top of the aspirator. The instrument should be handled with gentleness (Fig. 1617).

Remarks upon the operation of litholapaxy: Small stones may sometimes be caught in the eye of the catheter at the preliminary washing and removed. Or they may be removed by sucking into the tube of the evacuator. In cases in which it is known that there is a small stone in the bladder it may thus be removed without crushing.

The meatus should be enlarged to at least 28 French.

When cystitis is present, the operation should be preceded by a thorough irrigation of the bladder.

In cases with prostatic hypertrophy the patient may be placed in the extreme elevated pelvis position to cause the stone to gravitate away from the prostate. It may be necessary to rotate the lithotrite with the jaws backward in order to grasp such a stone. The finger in the rectum sometimes helps elevate the stone within grasp of the instrument. A stone too large to drop into the pouch behind the prostate may be grasped only by rotating the jaws forward.

The moderate distention of the bladder with water prevents catching the bladder wall in the lithotrite. In searching for stone it is best to open the jaws in the upright position, then rotate to the horizontal, and close them. If there is any difficulty in closing the lithotrite for withdrawal, it should be opened and closed repeatedly to liberate entangled pieces.

A fragment wedged in the eye of the tube may be too large to be withdrawn through the urethra. It may be dislodged with a stilet. If the tube is obstructed by the bladder wall being sucked into it, the stoppage is with a sudden jerk. In such a case more fluid should be pumped into the bladder.

The orifice of the tube should be turned in all directions to wash out pockets. This applies especially to the prostatic pouch.

It is well to wash out the urethra after the operation in order to remove any loose particles of gravel.

There should be no appreciable injury to the urethra. In old men slight bleeding may take place in the prostatic urethra.

There should be no tension in the bladder. Spasm of the bladder muscle should be prevented by anesthesia. When it does occur, the cock in the top of the aspirator should be opened and some fluid allowed to escape. It is possible to rupture a diseased bladder, by using too much fluid or by attempting to pump against a contracting bladder muscle.

After-treatment of lithotrity cases should be the same as for other bladder and urethral injuries. If the operation was done in the presence of infection, the treatment of that condition should continue. If there is an enlarged prostate, the traumatism of operation may cause congestion and complete obstruction. To avoid this, gentleness in manipulation should be practised. By fixing a catheter in the urethra for constant drainage, the comfort of the patient may be much improved. The reaction of the urine should be kept slightly acid.

It is well to wash out the bladder with a smaller tube in the course of a week or two in order to remove any particles which may have escaped. If there is reason to believe that calcareous matter is coming down from the kidney the operation should be repeated. With a small tube no anesthetic is required.

The bladder should be inspected about a month after operation; and the patient kept under observation for several years, as recurrence of stone is very common.

Perineal lithotrity may be done in cases in which there is a deep stricture of the urethra requiring external operation. After operating upon the stricture, the instruments are introduced into the bladder through the perineal wound and the stone crushed and removed. This may be done in cases in which to remove the stone unbroken would inflict serious damage upon the sphincter of the bladder.

Stone in the female bladder may be voided with the urine; it may be removed by dilating the urethra under cocain, and operating with long forceps or a snare, either with or without a speculum or endoscope; it may be treated by litholapaxy; it may be removed by cystotomy through the anterior vaginal wall (colpocystotomy) or above the pubes.

Litholapaxy has much to recommend it in women. It is easily done, and causes little after-disturbance. The patient is placed in the position for perineal operations. The handle of the lithotrite must be well elevated in order to throw the jaws far enough downward to grasp the stone.

Vaginal cystotomy is done with the patient in the dorsal position as for perineal operations or upon the side. A sound should be passed into the bladder and caused to bulge into the vagina. Upon this an incision in the median line is made just large enough to permit extraction of the stone with forceps. If infective cystitis is present the bladder should be permitted to drain until infection has been overcome, and then the operation for vesicovaginal fistula done. If the bladder is not infected, the wound may be closed at once, applying the same principles of operation as are applied in the treatment of vesicovaginal fistula.

If a large opening is not required, it is best to make a transverse incision only through the vaginal mucous membrane just back of the meatus. The mucous membrane is then dissected free to the bladder, and the bladder opening thus made at a location not opposite the vaginal opening.

Suprapubic cystotomy (page 214) is indicated in cases of very large or encysted stone.

Stone in the bladder in children is treated upon the same principle as in the adult. On account of the small urethra litholapaxy is not often to be considered. Suprapubic cystotomy will be found to be the operation of choice in most cases. By leaving in the urethra a catheter for constant drainage, the wound may be closed and primary healing expected. In young girls, suprapubic cystotomy should be preferred to colpocystotomy because of the small size of the vagina.

Foreign Bodies in the Bladder.—Bodies, other than calculi, may be removed through the urethra or by incision. In recent years the operating cystoscope has been used in removing many bodies, such as pieces of catheter, hair pins, bone, etc., which had formerly been treated by cystotomy. Ingenious forceps have been devised for removing such bodies. Lithotrity instruments may be used for friable material. Pieces of glass in the bladder are very serious and should be removed by suprapubic cystotomy.

Exstrophy of the Bladder.—This condition, in which the structures anterior to the posterior and basilar walls of the bladder are lacking, has been treated by many plans of plastic operation, devised to construct an anterior bladder wall. These operations have consisted mostly in turning over plastic flaps of skin in such a way as to furnish a skin lining for the new anterior wall (Fig. 1618). By these methods a sort of urinary receptacle has been made, but sphincteric control of the urine in it has been lacking (Fig. 1619). So that,

although the operations have succeeded in giving a front to the bladder, constant dribbling of urine has continued; and it is doubtful whether such operations are worth the pains (Fig. 1620).

Operations have also been devised for folding forward the outer edges of the remains of the bladder wall, and uniting them anteriorly, thus making a little bladder. Mucous-membrane-lined segments of intestine have also been used for the same purpose. However successful these operations have been, dribbling incontinence usually has continued. Epispadias also requires operation.

An operation, which has met with some favor, consists in carrying an incision like an inverted U along the sides and upper border of the bladder mucosa, dissecting down the bladder wall as a flap, and uniting it to the freshened edges of the penile gutter. If there is much preputial tissue, it is incised transversely, and brought up to cover partly or wholly the raw surface. Apparatus for covering the defect and collecting urine has been devised, and is fairly successful in keeping the patient dry (Fig. 1621).

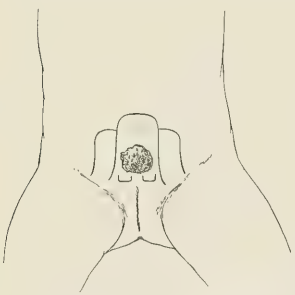


FIG. 1618.—OPERATION FOR EXSTROPHY OF THE BLADDER.
Showing skin incisions.

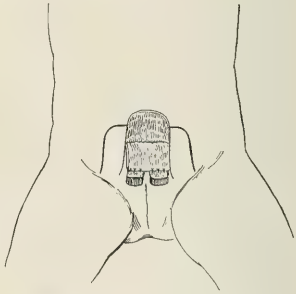


FIG. 1619.—OPERATION FOR EXSTROPHY OF BLADDER.
The median flap is turned down to give an epithelial lining.

The operative treatment which has proved most successful is carried out after the method devised by Maydl (Wiener med. Woch., xliv, 1894; Hartley, Annals of Surg., July, 1901). Ureteral catheters are introduced to carry off the urine during the operation. An incision is carried around the remains of the bladder wall and it is dissected free from the abdomen, care being taken not to disturb the connections of the ureters. An oblong segment of the bladder wall containing the two ureters is then cut out. This is about 4 to 5 cm. (1½ to 2 inches) broad and 2 to 2.5 cm. (¾ to 1 inch) high. A longitudinal incision is then made in the free border of the sigmoid flexure or rectum, and the segment of bladder wall sutured into it by two rows of sutures (Fig. 1622). The urine accumulates in the rectum, which soon develops a tolerance. The urine can be retained several hours. The operation may be carried out on the rectum as an extraperitoneal procedure. This operation has proved the most successful of any which has been attempted for this distressing condition. The immediate mortality in skillful hands is about 5 per cent. The great danger is that of ascending infection developing later. Some surgeons prefer sewing the whole of the bladder

wall into the bowel. Moynihan sewed a large area of bladder wall into the rectum, thereby increasing its capacity (Fig. 1623).

The operations described for implantation of the ureter (page 178) have been done for exstrophy. Implantation into the bowel is most worthy of consideration. When this is done the remaining bladder wall should be removed.

Implantation of the ureters into the cecum has been practised successfully. The cecum is cut off and the ileum connected with the ascending colon. The ureters are then anastomosed with the cecal pouch. An appendicostomy is performed, and the cecal bladder drained by a catheter until healing has been secured. By a plastic operation, the appendix may be connected with the urethra. The principle of muscular compression, which is used in making an artificial anus, may be applied to give control of urination.

Ascending infection is very prone to occur after any of these operations. Surgeons are coming to the conclusion that simple lumbar or abdominal implantation of the ureters with an opening through the skin and an apparatus to receive the urine is quite as satisfactory in many cases. Where only temporary drainage is desired, drainage through the skin is most satisfactory (see Construction of New Bladder, page 226).

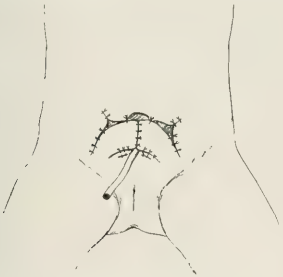


FIG. 1620.—OPERATION FOR EXSTROPHY OF BLADDER.
Completed operation.

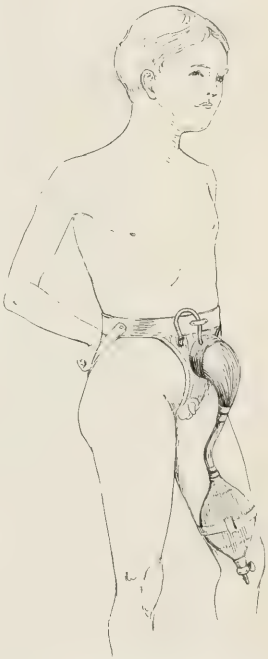


FIG. 1621.—APPARATUS FOR THE COLLECTION OF URINE IN CASES OF EXSTROPHY OF THE BLADDER OR INCONTINENCE.

In performing these operations, primary success is assured if the urine is diverted from the field of operation. This may be done by performing a preliminary lumbar ureterostomy. By permitting all of the urine to flow out behind, the operation may be done in a dry field, and the line of sutures is spared the irritation of a constant contact with urine. After the plastic operation has succeeded and the union is assured, in the course of a week or

two, the lumbar ureteral fistulæ may be closed, and the urine allowed to flow through the ureters.

Diverticula of the Bladder.—When bladder pouches are acquired, the condition is often associated with obstruction to the outflow of urine, the relief of which is the first requisite. Cystitis and fermentation of urine in a pocket should be treated. Regular catheterization or constant drainage may be employed to relieve intravesical tension. Stimulation of the bladder muscle by means of faradic electricity or strychnia is of service in some cases. The removal of stone from a pouch is essential for its cure.

In severe cases these palliative measures do not suffice, and a cure is to be secured only by operative excision of the pouch. Access to the pouch is secured by suprapubic incision. If possible it should be reached without opening the peritoneum. If situated at the base or posterior wall the sac is best attacked from within the bladder. By packing the diverticulum with gauze, it may be more easily dissected. An incision is made through the bladder wall about the base of the pouch, and the latter removed. The

FIG. 1622.—OPERATION OF MAYDL FOR EXSTROPHY OF BLADDER.
Segment of bladder with ureters sewed into sigmoid.

bladder opening is then closed by two rows of sutures, as described for wounds of that organ (page 216). If possible the space outside of the bladder, representing the site of the wound should be drained. The bladder wall should be kept relieved of tension for ten days by means of constant drainage through a catheter or the suprapubic wound.

For operating within the bladder the suction retractor, used in operations on the brain (Fig. 738, page 78, Vol. II), is useful. This may be inserted into the inside of the diverticulum, and the latter drawn into the bladder, being inverted, or turned inside out, as it follows the suction retractor. The base of the diverticulum may then be circumscribed by an incision, the inverted pouch removed, and the wound sewed. All this may be done through a suprapubic cystotomy opening.

Hypertrophy of the Bladder.—When hypertrophy is due to obstruction, the treatment consists in removing the cause. Hypertrophy due to irritation from cystitis, stone, or tumor is only relieved by removing the irritation.

Atrophy of the Bladder.—A bladder which has atrophied because of lack of function is capable of having its tone restored when it is again called upon to retain and expel urine. The principle and treatment are the same as in atrophy of other muscles and in atony of the bladder.

Atony of the Bladder.—Atony associated with retention of urine is the result of conditions causing (1) obstruction to the outflow of urine from the bladder, (2) nervous disturbances causing palsy of the detrusor muscles, (3) infection causing laming of the bladder wall and (4) voluntary prolonged retention of urine. It is obvious that the treatment consists in remedying the cause. After the removal of obstruction, a weakened bladder wall is capable of complete restoration to its normal function. The prognosis in paretic cases is not hopeful.

Tabetic atony can be helped by the passage of large sounds to cause thorough urethral dilatation, irrigation of the bladder with warm antiseptic solutions (silver nitrate), the administration of strychnia in large doses, and electrical stimulation of the bladder walls. Faradization is best applied with one electrode in the bladder. Vibratory massage to the lumbar and lower dorsal spine is of advantage.

The most important thing is to prevent the bladder from becoming distended. All that has been gained may be lost by a single overdistention. The bladder should be kept as nearly empty as possible. This should be insisted upon as an essential prerequisite to success. For this purpose, frequent catheterization or the placing of a catheter for constant drainage are necessary.

Sphincteric incontinence requires the treatment given for atony and paralysis. When due to division or rupture of the sphincter, caused by incision, cauterization, overdilatation or destructive disease, direct operation upon the sphincter is indicated, if the measures to cure atony do not succeed. (For sphincteric incontinence in the female, see Female Generative Organs, page 330.)

FIG. 1623.—IMPLANTATION OF SEGMENT OF BLADDER WALL WITH URETERS INTO RECTUM.

Incontinence of urine must be treated by treating the causative condition. When due to stricture, the dilatation or division of the stricture will effect a cure. Incontinence associated with an overdistended bladder due to prostatic obstruction requires radical treatment. Foreign body, such as stone at the internal meatus, causing incontinence, requires to be removed. When due to inflammation in the region of the internal meatus, such as trigonal cystitis or prostatic urethritis, treatment of the causative inflammation is called for. Tabes dorsalis, affecting the bladder, often before other symptoms appear, may be the factor requiring treatment. The same may be said of other lesions of the cord, and central nervous system, giving rise to bladder atony or palsy.

Enuresis.—Incontinence of urine requires first removal of the cause. The general health of the child should be improved. Vegetable diet diminishes diuresis. A light supper should be the rule, with no fluids during the three hours preceding bedtime. The child should be taught to arise and

urinate when the impulse prompts. Often it will be found advantageous to awaken the child at some time during the night to have it urinate.

Sources of reflex irritation should be searched for and removed. An elongated or adherent prepuce, adherent clitoris, or constricted meatus should be corrected. Intestinal worms and constipation should be cured.

When every discoverable cause has been eliminated certain medication, such as belladonna, has been of service in reducing reflex irritability. The gradual dilatation of the urethra by sounds helps in some cases. Faradism and galvanism applied to the bladder have been successfully employed. Cold douching of the genitals is useful. In some cases the injection of silver nitrate solution (1 : 1000) into the deep urethra has been of service. "Wetting the bed" is most apt to occur when the child is lying on its back. A brush or knot fixed to the back to prevent the dorsal position, by making it uncomfortable, may be tried.

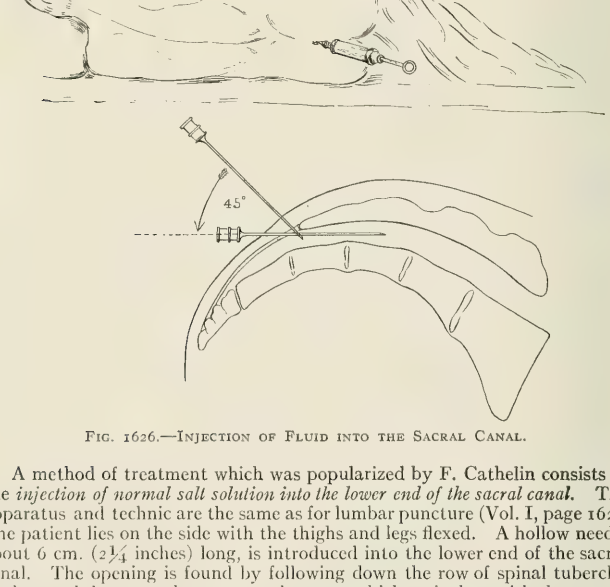


FIG. 1626.—INJECTION OF FLUID INTO THE SACRAL CANAL.

A method of treatment which was popularized by F. Cathelin consists in the *injection of normal salt solution into the lower end of the sacral canal.* The apparatus and technic are the same as for lumbar puncture (Vol. I, page 162). The patient lies on the side with the thighs and legs flexed. A hollow needle about 6 cm. (2¼ inches) long, is introduced into the lower end of the sacral canal. The opening is found by following down the row of spinal tubercles to the notch between the two sacral cornua which articulate with the cornua of the coccyx. The sacral canal contains the nerves which descend from the cauda equina. The needle enters the space containing these terminal sacral nerves. It should be passed upward its full length into the canal (Fig. 1626). This is called the epidural method.

About 10 c.c. (2 drams) are first injected. This amount may be gradually increased up to twice that amount. Injections are made every five days.

Five or ten treatments are required. The fluid should be injected slowly. Light chloroform narcosis may be employed (see Epidural Injections, Vol. I, page 162).

Vesical Hematuria.—Whether due to constitutional disease, such as scurvy, or hemophilia, or to local disease, such as circulatory disturbance, traumatism, infection, or tumor, the treatment should be that for the condition in which it occurs. In general, it may be said, if no diagnosis is made, the measures described for hemostasis may be employed. The bladder should be washed out until free from clots, and then the irrigation continued with some mildly astringent solution such as adrenalin, silver nitrate, or hydrastis. Extract of brain substance has proved effective as a local hemostatic. If these measures fail, the bladder should be opened and the bleeding dealt with directly. The cautery, suture, ligature, compression, packing, or other hemostatic measure may be applied, according to the cause of the bleeding (*q.v.*).

Hernia of the Bladder.—(See Hernia, page 51.)

Vesical Fistula.—The first requisite in the treatment of urinary fistula connected with the bladder is to provide a free natural urinary outlet. This means that before anything else is done the urethra should be examined and the slightest obstruction removed. Next cystitis should be cured. In some cases fistula may be cured by providing constant drainage of the bladder by means of a catheter, fixed in the urethra, or by a perineal cystostomy. These measures remove all internal pressure and the fistula remains dry and has an opportunity to contract and close. If these measures do not cure the fistula, operation should be done.

Freshening the fistulous tract with the curet, irritating it with pure silver nitrate fused on the end of a silver probe, or applying suction cups, are effective. These methods failing, or if there is much cicatricial tissue around the fistula, the fistulous tract should be dissected out.

Vesico-intestinal fistula requires abdominal section. The two viscera should be dissected apart and each opening closed by two layers of sutures. Constant drainage of the bladder should be provided for ten days (see Fistula, Vol. I, page 305).

Fistulas due to tuberculosis or cancer are not amenable to the above methods. They are to be cured only by eradication of the disease (for Vesicovaginal Fistula, see page 346).

Retention of Urine.—When due to *congenital disease*, an occluding prepuce should be removed by circumcision or should be perforated by incision, an imperforate or constricted meatus should be rendered freely patent, or an occluded urethra should be freed of obstruction by the gentle passage of a probe.

When *atonic overdistention* is present, due to depression of operation, nervous disorder, constipation, or prolonged voluntary retention, urine may be voided if an enema, consisting of 2 ounces of glycerin and a pint of warm soap suds, is given. Often the bladder will be emptied if the patient is placed in a warm bath and instructed to urinate while in the water. The recumbent patient who can not urinate may do so when he sits up or stands. The injection into the urethra of 15 or 20 c.c. of 2 per cent. boric-acid-glycerin causes about half of this fluid to enter the bladder, if force enough to overcome the sphincter is used. This stimulates the bladder to contract, and it usually empties itself soon after the injection. Catheterization should be used if these methods fail.

Retention due to *nervous disorder*, such as hysteria, spasm of sphincters, masturbation, nymphomania, tabes, scleroses, inflammations, pressure on

the cord or brain, and trauma, are to be treated by catheterization and treatment of the causative disease, when other methods fail. First the methods recommended for atonic retention should be used.

Retention due to swelling or spasm, caused by *acute inflammation of the deep urethra*, may be overcome by placing the patient in a hot bath and instructing him to void urine while in the water. No straining effort should be allowed. If the distention is not great, the patient may be given a hypodermic injection of morphin and atropin and put to bed on a hard mattress, with the expectation that the congestion or spasm will subside. The careful passage of a deep urethral syringe and the injection of adrenalin solution will often relieve the obstruction. Catheterization should be done if these methods fail.

Retention caused by *spasmodic stricture* is relieved by injecting cocain solution against the obstruction, and then passing a metal catheter or a sound, followed by a soft catheter. Ether narcosis should be employed if the patient is extremely nervous.

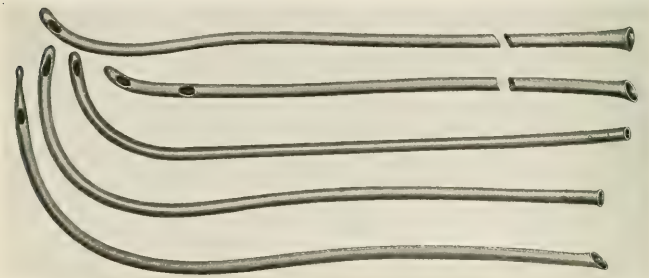


Fig. 1627.—Prostatic Catheters.
Various curves of catheters capable of riding over the enlarged prostate.

In cases of *inflammatory stricture of the urethra*, an attempt should be made to pass a small soft rubber catheter. This failing, adrenalin and cocain should be injected at the stricture and these followed in about five minutes by an injection of olive oil. With the urethra filled with olive oil, an attempt should be made with the soft rubber catheter, woven catheter, or metal catheter. These failing, the filiform bougie should be used. If the latter passes, it may be followed by others or the tunneled sound may be slipped over it. Sometimes after the passage of a filiform bougie a solid sound may be passed along side of it.

The urine being drawn, the patient should be put to bed and the curative treatment of the stricture deferred. If the stricture is found to be impassable the bladder may be emptied by suprapubic puncture (page 213). After this the patient may be able to pass urine. Suprapubic puncture may be repeated if the best time for operation has not arrived. If the stricture remains impassable perineal urethrotomy should be performed.

Perineal cystotomy should not be deferred, but should be done at once, in cases of impassable stricture in which many unsuccessful attempts at catheterization have been made. This is especially urgent if tears of the ure-

thra have been caused or if the attempts were by incompetent hands (see Stricture of Urethra, page 286).

Overdistention due to *rupture of the urethra* should be treated by immediate perineal urethrotomy.

In cases of *tumor compressing the urethra*, occluding *stone* or *foreign body*, the obstruction should be removed at once. *Abscess, hematoma*, or *urinary infiltration* of the perineum should be treated by perineal incision.

Retention caused by *prostatic hypertrophy* is very common in old men. The bladder is usually easily emptied by passing a catheter. The surgeon should be prepared with several forms. Besides the ordinary variety some forms are made especially for these cases. The coudé catheters of Guyon and Mercier are useful; also the metal catheter having a stronger prostatic curve (Fig. 1627). These instruments are made so that they will glide forward over the enlarged prostate. Small sizes should be used, 14 to 20 French. The catheter should be long because the urethra in these cases is

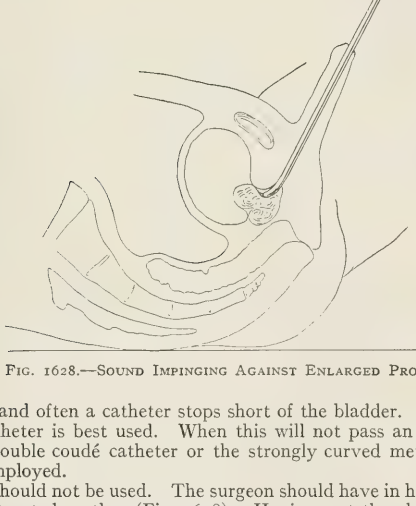


FIG. 1628.—SOUND IMPINGING AGAINST ENLARGED PROSTATE.

elongated and often a catheter stops short of the bladder. A coudé French rubber catheter is best used. When this will not pass an enlarged middle lobe the double coudé catheter or the strongly curved metallic instrument may be employed.

Force should not be used. The surgeon should have in his mind a picture of the obstructed urethra (Fig. 1628). Having met the obstruction the tip of the instrument should be directed forward, and when the upper level of the obstruction is reached, the instrument should be lifted forward and directed backward (Fig. 1629).

As a rule an ordinary soft rubber catheter of small size passes a prostatic hypertrophy without difficulty. It is only when this fails that the special instruments are necessary. When the obstruction is due to an enlarged lateral lobe, the catheter will be deflected to the side. In such cases the woven catheter with an elongated and tapering end should be used.

Catheterization failing, suprapubic puncture should be done and the bladder emptied. When the bladder has again filled, catheterization should again be attempted. Suprapubic aspiration may be repeated two or three times until the patient has been catheterized or is ready for suprapubic or perineal cystotomy as a preliminary to removal of the prostate. If puncture is required more than 2 or 3 times, it is better to perform suprapubic cystotomy and establish constant drainage. If the urethra has been severely damaged and blood clots are found in the urine it is best to proceed at once with suprapubic cystotomy.

In cases of *thickening of the prostatic isthmus, bar, or contracture at the vesical meatus,* a soft catheter can usually be passed.

Retention due to *carcinoma* of the urethra or penis demands perineal or suprapubic drainage.

Obstruction due to *stone* in the bladder is relieved by catheterization.

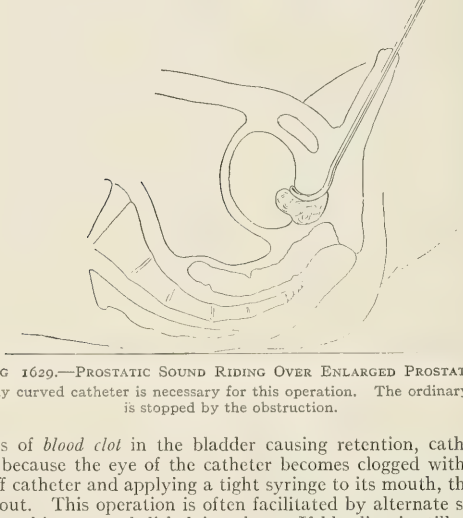


FIG 1629.—PROSTATIC SOUND RIDING OVER ENLARGED PROSTATE.
The especially curved catheter is necessary for this operation. The ordinary instrument is stopped by the obstruction.

In cases of *blood clot* in the bladder causing retention, catheterization often fails because the eye of the catheter becomes clogged with clot. By using a stiff catheter and applying a tight syringe to its mouth, the clot may be sucked out. This operation is often facilitated by alternate suction and injection, breaking up and dislodging clots. If bleeding is still going on in the bladder, it should be checked by the means already described (see Vesical Hematuria). Very solid clot may require to be broken up with a sound or lithotrite. These measures failing, cystotomy should be done.

Retention caused by *cystitis* or *bacteriuria* is to be relieved by catheterization and treatment of the disease.

In general it should be understood that measures for causing voluntary and spontaneous evacuation of the bladder should first be thought of. When instrumentation is necessary, the soft rubber catheter is the instrument of choice. It often happens that a small catheter fails to pass because it

engages in a pocket when a larger catheter would succeed. Metal instruments are to be used when soft ones are of no avail. Suprapubic aspiration of the bladder is the next step; and cystotomy (suprapubic or perineal) is the final resort.

Operations on the Bladder

Suprapubic aspiration of the bladder is done for acute retention not relieved by catheterization. Percussion and palpation should show the distended bladder rising above the pubes. The parts should be shaved and the skin cleansed and rendered aseptic as for operation. An anesthetic is not necessary. An aspirating needle or trocar and canula is used. The needle should be about 2.5 mm. in diameter. The puncture should be made exactly in the middle line, just above the pubes, close to the bone. The needle should pass backward and slightly downward. It penetrates 4 to 6.5 cm. (1½ to 2½ inches) to pierce the bladder. This distance varies with the amount of fat present. There is no danger of puncturing the peritoneum

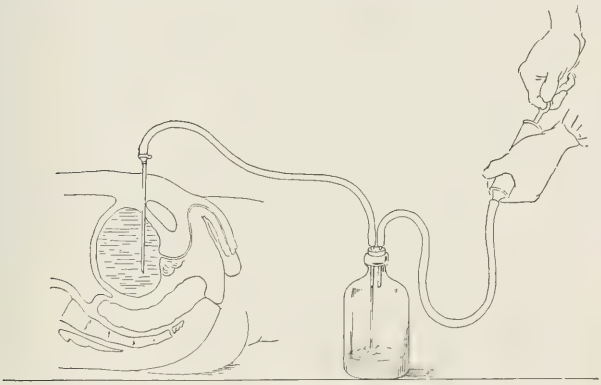


Fig. 1630.—Suprapubic Aspiration of Bladder.

if the surgeon makes sure that the bladder is distended enough to raise it above the pubes, as it lifts up the peritoneum with it (Fig. 1630).

Suprapubic canulization is suprapubic drainage of the bladder secured by means of the introduction of a canula with a trocar. For this purpose the ordinary trocar and canula may be used, or the special suprapubic apparatus may be employed. This latter is so constructed that when the trocar is withdrawn, a rubber tube may be connected with the canula and permanent drainage established. The canula is provided with a shoulder which enters the bladder and prevents forward displacement. Another shoulder on the tube prevents backward displacement. The tube is passed into the bladder until one shoulder is just within the bladder. The trocar is then withdrawn and a rubber tube slipped over the canula. An outer shoulder and the rubber tube itself prevent displacement into the bladder. This operation may be done under local analgesia or gas-oxygen anesthesia. A tube having a caliber of 5 or 10 mm. is used.

Suprapubic cystotomy is the most useful and widely applicable operation for securing access to the interior of the bladder. It is indicated for the removal of stones (particularly in cases of large ones or sacculated small stones), for drainage, for the removal of foreign bodies, for treatment of diseases of the mucous membrane of the bladder, for the removal of tumors, for ureteral calculi, and for operations on the prostate. Complete narcosis or local anesthesia is employed.

The pubes should be shaved. The bladder should be filled with fluid. In cases of unrelieved retention the bladder is already distended. When a catheter can be passed, enough boric acid solution should be injected to distend the organ. This requires 240 to 300 c.c. (8 or 10 ounces). The patient should be placed in the lowered head position of Trendelenburg. This helps the bladder to gravitate upward out of the pelvis. As the catheter is withdrawn, after injecting the fluid, a tape or rubber band should be thrown about the penis to keep the fluid in the bladder. If the bladder holds but little fluid, a rubber bag may be introduced into the rectum or vagina and distended with air or with 300 or 350 c.c. (10 or 12 ounces) of water to lift up the bladder.

Instead of using fluid to distend the bladder air may be used. It has the advantage that it is light and tends to float the bladder upward. The disadvantage is that the amount cannot easily be measured and overdistention may occur. In the case of ulcerated or badly diseased bladder there is danger of rupture with any form of distention. Many surgeons employ none of these measures, but pass a good-sized sound, press its tip forward above the pubes, and dissect down upon it. Complete general anesthesia is best if the bladder is to be distended with fluid.

An incision 7.5 or 10 cm. (3 or 4 inches) long is made in the median line just above the pubes. The recti and pyramidales muscles are separated by blunt dissection, retracted away from the median line, and the fatty tissue lying between the upper border of the pubes and the peritoneum exposed. This space varies in height from 1.25 to 5 cm. (½ to 2 inches) in different individuals and in different degrees of distention of the bladder. A fascia in some cases holds the peritoneum close down to the pubes. If the prevesical space is not at once entered, this fascia should be divided by a transverse incision close to the upper edge of the bone.

The dissection through the prevesical fat and areolar tissue toward the bladder should begin at the pubes and work carefully backward. As soon as the peritoneum is discovered above it should be covered by a flat pad and held upward with a retractor. The bladder is recognized by its convex contour, firm consistency, pink color, muscular striations and fluctuation. All bleeding vessels should be ligated and the tissues retracted clearly to expose the bladder.

The bladder wall is grasped with two tenacula penetrating all of its coats excepting the mucous membrane. The tenacula are placed 1 cm. (⅓ inch) apart horizontally opposite one another. The bladder is then opened by a vertical median incision between the two tenacula which are held by an assistant and steady the bladder wall while the incision is made. It is often possible to place this incision so that it does not divide conspicuous vessels. If there are prominent vessels, crossing the median line, they may be included in mouse-tooth forceps which may be used in place of tenacula (Fig. 1631).

The bladder should not be opened by quickly plunging a knife through its wall. Modern surgery no longer plunges a knife into anything. The bladder should be opened by short dissecting strokes, incising each layer of its wall for a short distance, and when the last layer has been incised the bladder is

open and its contents gush forth. The tenacula are then used to hold the organ while the wound is enlarged if necessary. The fluid, as it escapes from the bladder, should be prevented from running into the prevesical space by closing the space with gauze or by drawing forward the bladder. The constriction about the penis should be released. If a colpeurynter had been used it should be removed.

The surgeon then proceeds to carry out the special object of the operation. In order to secure a better view of the interior of the bladder, retractors may be inserted within the viscus. An electric light is of much service in illuminating its interior.

FIG. 1631.—SUPRAPUBIC CYSTOTOMY.
Traction sutures support the bladder. A retractor draws upward the vesical reflection of peritoneum.

If no infection is present, if the escape of urine through the natural exit is free, and if no lesion remains, the bladder may be closed. This is done by a chromic catgut suture including all of the coats but the mucous membrane (Fig. 1632). This suture should emerge at the edge of the wound just external to the mucous membrane. It should be covered by a second suture. Both rows of suture should be drawn tightly (Fig. 1633). The overlying structures should be sutured in two layers, and the whole wound closed excepting the lower angle through which a drain should be carried down to the bladder. This drain is for the purpose of carrying to the surface urine in case the bladder wound does not remain tight, leakage of urine into the prevesical connective tissue being fraught with serious consequences. The drain may be removed at the end of thirty-six hours.

After closing the bladder the care of the patient should be the same as described for wounds of that organ (page 190).

If drainage is necessary because of infection, urethral obstruction, or disease of the bladder, a good-sized rubber tube should be placed in the

FIG. 1632.—CLOSING SUPRAPUBIC BLADDER WOUND.

Traction sutures support the two ends of the wound. A continuous suture is applied. It includes all coats except the mucous membrane and is interrupted several times by tying.

opening. The bladder wound should be closed down to the tube, and the wound made water-tight by means of a purse-string suture tied around the tube (Fig. 1634). A small drain should be placed below the tube as far

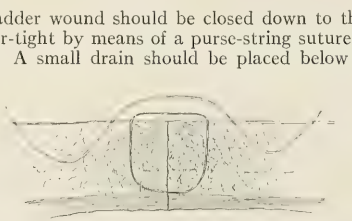


FIG. 1633.—CLOSURE OF WOUND AFTER SUPRAPUBIC CYSTOTOMY.

Two rows of continuous suture are applied. The first row catches the whole thickness of the bladder wall excepting the mucous membrane. The outer row catches the superficial structures.

as the bladder. The rest of the superficial wound should be closed (Figs. 1635 and 1636). The tube should be connected to a receptacle at a lower level than the bladder into which the urine may syphon.

In some cases in which there is pronounced infection, or in which extensive disease of the bladder wall is present, no closure of the wound at all is to be attempted. The bladder edges are sutured to the deep fascia and a tampon of gauze introduced.

A suprapubic urinary sinus remaining after cystotomy will close spontaneously if the natural escape of urine is free and if there is no disease of the bladder or sinus.

Some surgeons prefer a *transverse suprapubic incision* in this operation. The incision is semilunar, concavity upward, 15 cm. (6 inches) long, about 2.5 cm. (1 inch) above the symphysis, and passes through all the structures

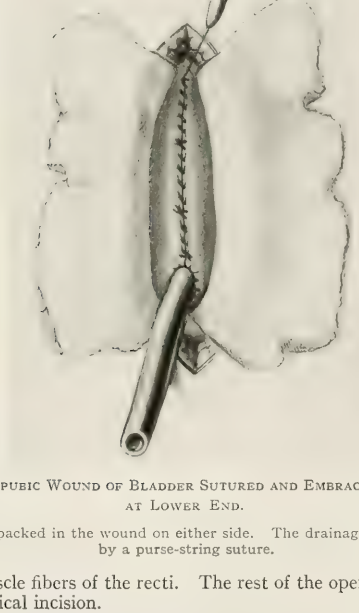


FIG. 1634.—SUPRAPUBIC WOUND OF BLADDER SUTURED AND EMBRACING DRAINAGE TUBE AT LOWER END.

A gauze sponge is packed in the wound on either side. The drainage tube is held tightly by a purse-string suture.

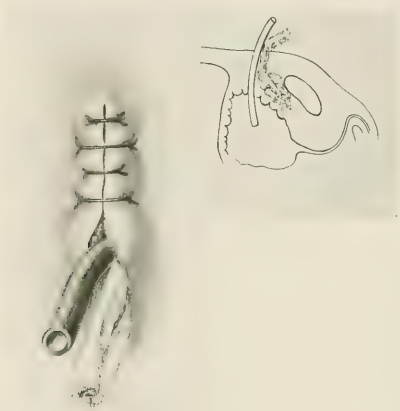
down to the muscle fibers of the recti. The rest of the operation is the same as with the vertical incision.

Perineal cystotomy may be done in the median line or laterally. The lateral operation affords more room than the median, and there is less danger of wounding the bulb of the corpus spongiosum and rectum. In the median operation there is a smaller wound, less bleeding and quicker healing. The rectum should be empty, and the perineal and pudic regions shaved. The patient should be placed on the back, with knees and thighs flexed, and brought down so that the buttocks project below the end of the table. The pelvis should rest on a sand-bag or cushion. The legs should be fixed and supported by some apparatus attached to the table in such a

manner as not to place too much strain on the ligaments of the hips (Fig. 1495, page 54). All of the parts excepting the perineum should be covered with sterile protectors. The scrotum is held up by a moist towel. The surgeon sits at the foot of the table facing the patient's perineum. Assistants stand on either side.

An assistant, standing on the patient's left, holds in his right hand a grooved staff or a sound which has been passed through the urethra to the bladder. The handle of the staff should at first be depressed nearly to a horizontal position so that the curve of the instrument bulges prominently in the perineum. After the surgeon has cut down upon it the handle should be elevated to a perpendicular position and the tip caused to enter the bladder.

In many instances the operation of perineal cystotomy need not be fully carried out. It may often stop at perineal urethrotomy, and sufficient



FIGS. 1635 and 1636.—SUPRAPUBIC WOUND CLOSED.
The rubber tube drains the bladder. The gauze drain passes down to the prevesicle space external to the bladder.

access to the interior of the bladder thus secured. As a matter of fact that is what many perineal cystotomies are.

For *lateral perineal cystotomy* the incision in the adult is begun at a point about 8 mm. (⅓ inch) to the left of the median line and 3.75 cm. (1½ inches) anterior to the anus. It is carried backward and to the patient's left to a point midway between the tuberosity of the ischium and the anus. This incision should be about 6.5 or 7.5 cm. (2½ or 3 inches) long (Fig. 1637). The structures first divided are the skin and fasciæ, transverse perineal muscle, small transverse perineal and hemorrhoidal vessels and nerves, and lower edge of triangular ligament. The staff is now felt for with a finger in the wound and the handle elevated. The point of a narrow-bladed knife is then guided by the index-finger of the left hand to the staff at the anterior or upper part of the wound. The point of the knife reaches the guide and is carried backward, the cutting edge being directed toward the left and downward. The knife follows the guide and passes through the

upper border of the prostate gland and sphincter of the bladder. The entrance of the knife into the bladder is signalized by a gush of urine. The knife is then withdrawn. The structures cut by the deep incision are membranous and prostatic urethræ, triangular ligament, compressor urethræ muscle, anterior border of levator ani muscle, the border of the left lateral lobe of the prostate, and sphincter muscle of the bladder. The parts to be avoided by the knife are the bulb of the corpus spongiosum, the artery of the bulb, the rectum, ejaculatory duct and the internal pudic artery.

The bladder being entered, the guide should be left in place until stone forceps, scoop, gorget or other instrument, required by the case, is introduced.

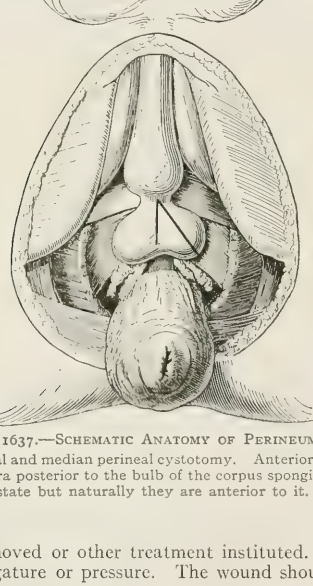


FIG. 1637.—SCHEMATIC ANATOMY OF PERINEUM.

Showing lines of lateral and median perineal cystotomy. Anteriorly the lines of incision rest upon the deep urethra posterior to the bulb of the corpus spongiosum. The incisions appear to lie on the prostate but naturally they are anterior to it. The rectum is here shown dissected free.

A stone may be removed or other treatment instituted. Bleeding is controlled by clamp, ligature or pressure. The wound should be closed with drainage.

For *median perineal cystotomy*, the same preparation is required as described for the lateral operation. The preliminary steps of the operation are the same. It is the simplest and safest route to the bladder, but gives less room than the suprapubic or lateral perineal operations. The incision being placed in the median line bleeding is minimized and healing is hastened.

A grooved staff is introduced into the bladder and cut down upon in the median perineal line. The incision begins about 1½ inches (4 cm.) anterior to the anus and extends backward about 1 inch (2.5 cm.). The surgeon dissects down to the staff in the urethra, keeping posterior to the bulb. The urethra being incised in the middle line, the incision is carried

backward to the apex of the prostate gland Further dilatation may be secured by means of uterine dilators if necessary.

The older surgeons did the operation with one plunge of a double-edged knife. If haste is necessary, the operation may be done by directly passing the knife-point first into the bladder. To avoid cutting the rectum the index-finger of the left hand may be inserted into the bowel as the incision is made. The apex of the middle lobe of the prostate is cut in the rapid operation.

A straight director or gorget is introduced into the bladder through the wound and the urethral guide removed. The object of the operation is then proceeded with, after which a drainage tube is introduced as described above. Even though no bladder disease exists which should require drainage, a tube may be employed. The danger of urinary infiltration is so slight that in clean cases tubes may be dispensed with, and the wound simply covered with a gauze dressing.

For *perineal drainage of the bladder* a rubber tube is used. The tube should be between 1 and 1.3 cm. (⅜ and ½ inch) in diameter, preferably with one or two fenestra near the end. The tube should be 15 or 18 cm.

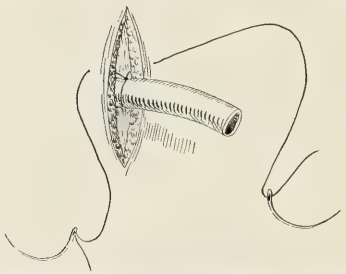


Fig. 1638.—Tube Drainage in Perineal Cystotomy.

(6 or 7 inches) long, firm enough not to collapse easily. The operation upon the bladder being completed the tube is introduced so that about 2.5 cm. (1 inch) lies within the bladder. A silkworm-gut suture is then thrown around the tube, two turns being taken in the first tie, and the suture tied tightly enough to sink into the rubber to insure against slipping. Each end of the suture is threaded on a curved needle and passed through the edges of the perineal wound. The needles should catch the deep structures and pass out through the skin about the middle of the wound. The suture is tied across the wound (Fig. 1638). One or two more sutures are applied above this to close the anterior end of the wound. The rest is left open to receive a narrow strip of gauze, passed in as far as the prostate, and to be left in place for a day or two. The bladder should then be washed out through the tube to insure its patency. A copious gauze dressing, through the middle of which emerges the tube, is held in place by a T-bandage. As the patient is put in bed, a longer tube should be connected to the drain and carried to a bottle at the side of the bed.

The length of time that perineal drainage is maintained depends upon the lesion for which it is applied. If no disease requiring drainage is present, the tube is employed to prevent infiltration of the wound region

with urine, and the tube should be left in until the cellular spaces have become covered by granulation tissue. Two days is long enough for this. The tube should be inspected frequently to see that it is draining. If it becomes clogged by clot or other substance it may be freed by irrigation. After its removal, a perineal sinus discharges urine for a variable time, the speed of its closure depending upon the freedom of the urethra from obstruction.

Transperitoneal cystotomy is an extremely hazardous operation, compared with those cystotomies which do not involve exposure of the peritoneal cavity. It is justified only when the bladder has been opened accidentally through the peritoneum and in cases in which a larger opening must be added for the removal of disease. Even in these cases, if possible, it is best to close the wound and do a suprapubic or perineal cystotomy. Transperitoneal incision of the bladder must be made in some operations for cystectomy and for uretero-cystotomy.

Permanent drainage of the bladder may be secured by urethral catheter or through any of the openings made for vaginal, suprapubic or perineal cystotomy. Any tube which is allowed to remain in the bladder excites secretion of mucous and invites the precipitation of mineral salts from the urine. It should be removed and cleansed at least once or twice a week.

When *vesicovaginal drainage* is desired, it is only necessary to leave open and unsutured the vesicovaginal cystotomy wound (page 203). The urine freely passes into the vagina and thence escapes and should be caught in a copious pad worn for that purpose. This should be regarded only as a temporary expedient as it is not at all agreeable for the patient. If the vesicovaginal fistula does not heal spontaneously an operation for its cure should be done after the drainage is no longer needed.

For securing *suprapubic drainage* without leakage a tight-fitting tube is necessary. Such a drain may be made tight by inserting first a tube with a thin and elastic wall, and then inserting inside of this a second tight-fitting tube which is slightly larger than the caliber of the outer tube, thus causing distention as it is introduced. The urine conducted from such a tube may be conducted into absorbent gauze, into a vessel at the side of the bed, or into a rubber bag worn on the leg. A suprapubic tube may be retained by means of pressure, secured by a belt around the body, by the use of adhesive plaster, or by an enlargement on the inner end of the tube.

H. P. Jack adapted the Murphy button to the bladder after the same principle as applied by W. D. Johnson in gastrostomy. One-half of the button is inserted tightly into the end of a large rubber tube. The other half of the button, with a rubber ring around its shank, is inserted into the bladder through a small slit, or held by a purse-string suture. When the two halves are pressed together the wound is hermetically sealed. If irrigation of pockets is desired a small catheter may be passed to the bottom of the bladder through the rubber tube. The button cuts out in about two weeks (Jour. Am. Med. Assoc., April 27, 1918).

A very useful suprapubic tube is made of rubber with a mushroom-like enlargement at the end. This may be held forward by external traction (Fig. 1639).

A rubber elastic apron, passing around the body and doubled upon itself so as to make a tube, may be devised for holding and conducting off urine from a suprapubic fistula.

The suprapubic opening may be made in the form of a valve by applying two or three rows of sutures around the tube and causing the bladder wall to

be inverted as is done in gastrostomy (see Suprapubic Aspiration and Suprapubic Canulization, page 213).

It is not often necessary to continue for a long time *perineal drainage* by means of a tube, although the drainage may continue itself if nature needs it. The tube is inserted through the perineal opening of a perineal urethrotomy of cystotomy. A self-retaining tube may be used to obviate the necessity or external fixation. Such tubes may be extemporized or the ready-made *self-retaining catheter* may be employed. It should be removed at least every third day and cleansed and the bladder irrigated. Urine is conducted through a connected tube into a receptacle below the bed.

For permanent *urethral drainage* the fixed catheter (*catheter à demeure*) is employed. A soft rubber catheter of a comfortable size is left resting in the bladder just far enough to insure good drainage. It is made fast by means of an adhesive strip, embracing the catheter, laid along the sides of

FIG. 1639.—SELF-RETAINING CATHETER FOR SUPRAPUBIC DRAINAGE.
Showing construction of end.

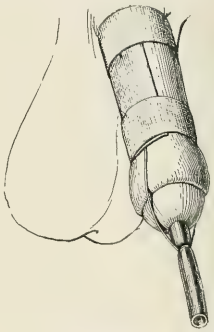


FIG. 1640.—CONTINUOUS URETHRAL DRAINAGE OF BLADDER (INLYING CATHETER, RETENTION CATHETER, *Catheter à demeure*).
A silk thread, tied about the catheter, is held to the penis by adhesive strips.

the penis and secured by a bandage (Fig. 1640). In the absence of adhesive plaster a tape may be tied around the base of the penis and scrotum. To this, silk threads are tied which hold the catheter. A bandage should be placed about the penis to confine the threads, and the skin should be powdered.

In the female a silk thread may be tied around the catheter and the two ends made fast on either side to a wisp of pubic hair. The permanent catheter is often not well borne and must be dispensed with after two or three days.

An extemporized device uses the finger of a rubber glove to hold the catheter. It is divided lengthwise up to within 12 mm. ($\frac{1}{2}$ inch) of the end. The catheter is passed through a small hole in the tip. The four strips are held against the penis by a rubber strap cut from some other part of the glove, and passed through slits.

Suction drainage of the bladder may be secured by the siphon principle or by other mechanical devices, and is applied to the suprapubic or urethral tube.

One of the most effective methods is that devised by Dawbarn (Fig. 1641) (Annals of Surgery, vol. 23, page 499). The apparatus consists of a 4000 c.c. (1 gallon) reservoir (*R*), to contain water, and a Y-tube (*Y*) connecting it with the bladder (*B*). A clamp (*S*) between the reservoir and the Y-tube permits the water to flow drop-by-drop. A trap (*T*) is made by a loop in the tube held by an elastic band. The outflow of water and urine is received in the waste pail (*W*) in which the end of the tube may be kept immersed by a weight. The screw should be regulated so that several hours are required to empty the reservoir. Water flows until the trap (*T*) is completely filled, then the next drop that enters it causes a rapid emptying of the trap and the tubes above it. A vacuum is thus created above the trap, and the air pressure upon the urine in the bladder forces it into the tube, and the bladder is emptied by siphonage. This is repeated every time the trap becomes full. In order that air may enter the bladder, it is desirable that a large-sized tube be inserted into the suprapubic opening, and a stiff tube or catheter, having two openings close to the end, be inserted to the bottom of the bladder through this. There should be space enough between the two tubes to permit the entrance of air into the bladder.

To wash out the bladder, irrigating solution is used in the reservoir (*R*). The tie constituting the trap (*T*) should be undone, and the clamp (*S*) loosened. By pinching alternately at the points *A* and *B* the fluid alternately runs out of the bladder and into the bladder.

To collect the urine separately from the water from the reservoir, for purposes of measurement or analysis, the tube may be cut at the point *C*, and each arm connected with a chemist's wash bottle, provided with two glass tubes passing through a rubber stopper.

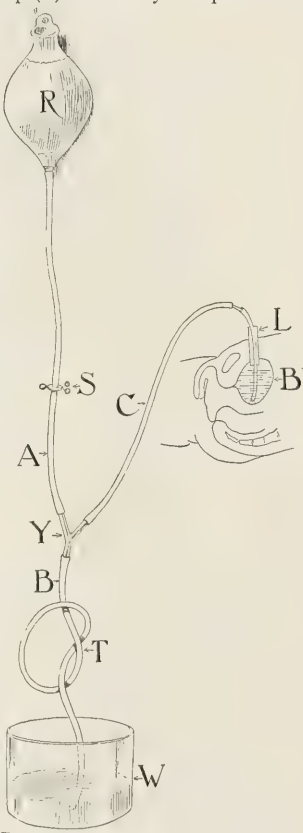


FIG. 1641.—SIPHON DRAINAGE OF BLADDER.

Another suction drainage apparatus is that devised by F. E. Fee (Lancet Clinic, Feb. 4, 1911). It consists of a 4000 or 8000 c.c. (1 or 2 gallons) bottle filled with water and a 1000 c.c. (1 quart) bottle to receive the urine. The large bottle allows the water to escape at the bottom at the rate of 10 c.c. (150 drops) per minute. The two bottles are connected by tubes through rubber stoppers. As the water level falls a vacuum tendency is

rceated in the two bottles and the urine is aspirated from the bladder (Fig. 1642). Instead of allowing the water to run away into a waste receptacle it may flow into a second lower water bottle, which when full may be elevated to the place of the first.

The suction drainage device of N. H. Beal (Surg., Gyn. and Obst., December, 1917) consists of a very simple siphon apparatus, whereby a glass tube empties itself of water at regular intervals (Fig. 1642*a*). The flow of water through the rubber tube from the siphon causes the suction upon the tube which is connected with the bladder (Fig. 1642*b*).

Resection of the bladder is usually done for the removal of a tumor of the bladder wall. The part of the bladder bearing the tumor is resected and the wound closed as for cystotomy. The method of approach must vary with the location of the disease. A tumor at the top of the bladder may be reached by the suprapubic route and by pushing back the peritoneum. It may be necessary in some cases to dissect free the peritoneum for some distance. If the peritoneum must be opened, the general peritoneal cavity should be separated from the field of operation by stripping up the peritoneum and suturing it. A tumor involving that part of the bladder which is covered by peritoneum may be removed through the suprapubic cystotomy opening without incision of the peritoneum at any place. A tumor involving the ureteral openings may require so much resection that ureteral implantation in the rectum may be necessary, but if there remains enough bladder wall to make a pouch which can be connected with the ureters and urethra by all means it should be preserved. After resection of the bladder a drain should be carried down externally to the wound and a catheter left in the urethra.

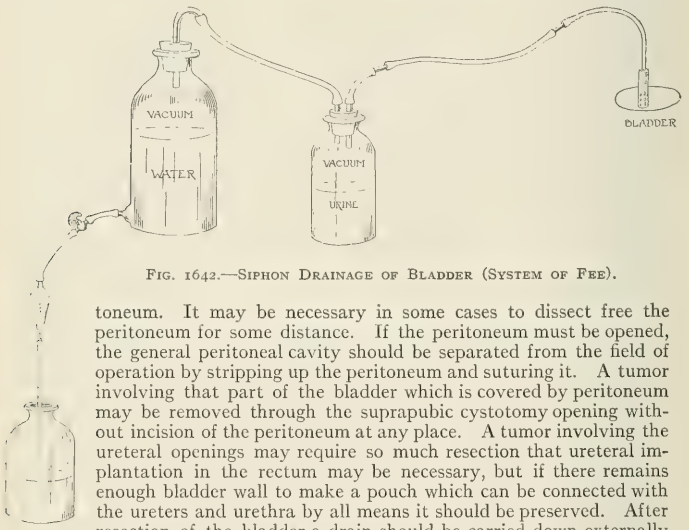


FIG. 1642.—SIPHON DRAINAGE OF BLADDER (SYSTEM OF FEE).

The *transperitoneal route for the removal of bladder neoplasms* gives a wider approach than is secured by the extraperitoneal method. In skilled hands it has given good results. Some surgeons prefer this route in resections for *papilloma*. The location of the tumor being determined by cystoscopy, the bladder is opened, and the tumor if pedunculated, excised by the cautery, and the base left to granulate. Often much of the bladder wall must be removed, and ureters transplanted into the remaining part of the wall. The wound is closed by the same method as employed in closing wounds of the stomach. A tight, two-layer suture should be applied. Peritoneal drainage is not necessary.

Cystectomy (total removal of the bladder) is done for malignant neoplasms confined to that organ. The patient is placed in the lowered head position of Trendelenburg and a median incision is made from the pubes 10 or 12.5 cm. (4 or 5 inches) upward. This is crossed at its lower extremity by a transverse incision, extending from one inguinal ring to the other, and following the upper border of the pubes. The two triangular flaps are dissected away from the recti muscles and the bladder approached in the middle line, between muscles. The bladder should be dissected from the pubes, and the dissection continued as far as the urethra. In the lateral dissection the inferior vesical arteries are ligated. If not involved in the disease, the peritoneum should be dissected from the bladder without opening the peritoneal cavity. The ureters are

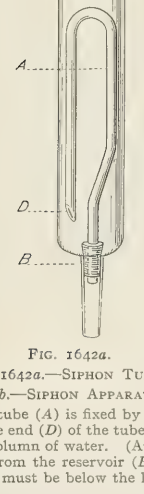


FIG. 1642a.

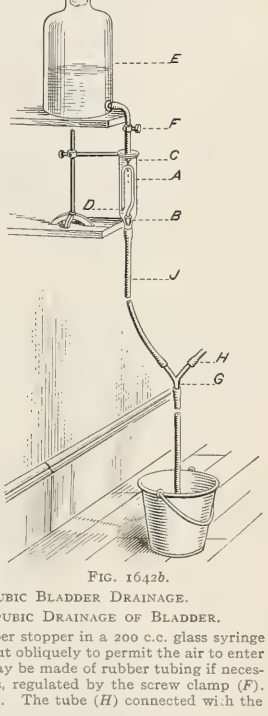


FIG. 1642b.

FIG. 1642a.—SIPHON TUBE FOR SUPRAPUBIC BLADDER DRAINAGE.

FIG. 1642b.—SIPHON APPARATUS FOR SUPRAPUBIC DRAINAGE OF BLADDER.

The curved tube (*A*) is fixed by means of a rubber stopper in a 200 c.c. glass syringe barrel (*C*). The end (*D*) of the tube (*A*) should be cut obliquely to permit the air to enter and break the column of water. (An oblique end may be made of rubber tubing if necessary.) Water from the reservoir (*E*) flows in drops, regulated by the screw clamp (*F*). The *Y*-tube (*G*) must be below the level of the body. The tube (*H*) connected with the bladder.

divided. The urethra is amputated at the bladder. Before amputating the urethra or opening the bladder, the urine should be drawn off through a catheter, and, if infected, the bladder irrigated with antiseptic solution. After removal of the bladder the ureters are implanted in the rectum, sigmoid colon, drained through the loins, or the first steps in reconstruction of a new bladder are made. The wound is packed and drained.

In some cases of involvement of the peritoneum the best approach is secured by operating through the peritoneal cavity. When this is done, the

intestines should be protected by pads. The peritoneum which is involved in the disease is removed with the bladder, and the edges sewed together after the cystectomy.

The **construction of a new bladder** is among the possibilities after cystectomy. The sigmoid colon lends itself best for the purpose. When the cystoscopic examination shows that a total removal of the bladder is required, the following steps may be taken: (1) Double pyelostomy, accomplished by lumbar pyelotomy and drainage. (2) Cystectomy at the same sitting, or, if the condition of the patient demands it, at a later sitting. (3) Isolation of the sigmoid colon by amputation of the bowel in two places, closing the

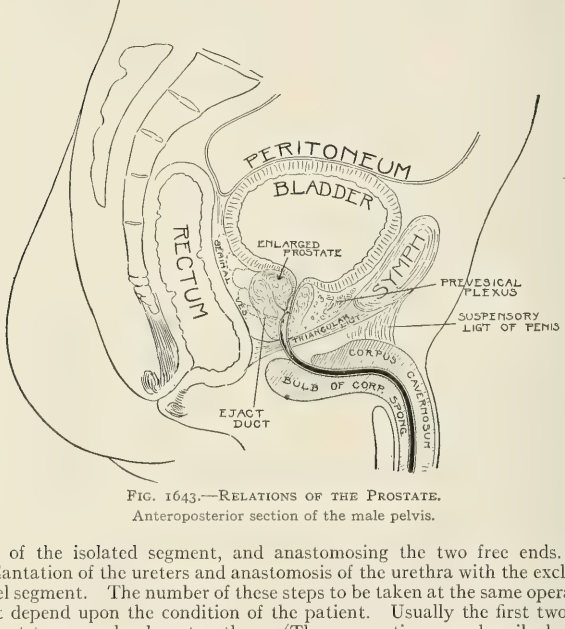


FIG. 1643.—RELATIONS OF THE PROSTATE.
Anteroposterior section of the male pelvis.

ends of the isolated segment, and anastomosing the two free ends. (4) Implantation of the ureters and anastomosis of the urethra with the excluded bowel segment. The number of these steps to be taken at the same operation must depend upon the condition of the patient. Usually the first two and the last two may be done together. (These operations are described under their respective headings above.)

THE PROSTATE GLAND

Anatomy.—The prostate is the analogue of the uterus. It is situated at the base of the bladder, between that organ and the rectum, and embraces the urethra as it emerges from the bladder. It is somewhat pyramidal in shape, the base lying against the bladder and the apex is directed forward and is fixed to the deeper layers of the triangular ligament. The posterior surface rests upon the rectum. It is about 3 to 4 cm. (1½ inches) long. The transverse diameter is 4 to 5 cm. (1½ to 2 inches). It is incorporated with the muscular wall of the bladder anteriorly, but posteriorly it is free from the bladder (Fig. 1643).

The *capsule* is formed by a coalescence of the muscular sheath of the organ and the enveloping pelvic fascia. The complicated reflections of the rectovesical fascia bind the prostate to the surrounding structures. The periprostatic plexus of vein lies in the layers of

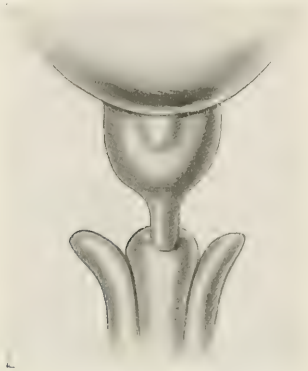


FIG. 1644.—THE PROSTATE (ANTERIOR VIEW).

the rectovesical fascia. The arteries which supply the prostate are small (Fig. 1644) The *seminal vesicles* lie above the prostate, converging anteriorly. The levatores ani mus-

FIG. 1645.—THE PROSTATE (POSTERIOR VIEW).
Showing vasa deferentia and seminal vesicles.

cles are laterally. The recto-urethralis muscle connects the membranous urethra and the anterior wall of the rectum, being a median part of the levator ani (Fig. 1645). The sper-

matic ducts pass through the substance of the gland. In prostatectomy they are avoided by separating the two lateral lobes one from the other and leaving the ducts between uninjured. The ducts pass between the lobes below the urethra and empty at the sides or in

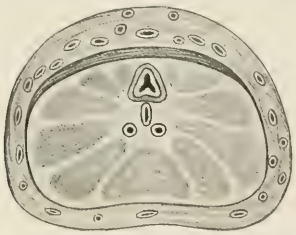


FIG. 1646.—VERTICAL TRANSVERSE SECTION THROUGH PROSTATE.
Showing vascular capsule, urethra, prostatic utricle (the homologue of the vagina) below urethra, and the two ejaculatory ducts below the utricle.

FIG. 1647.—INCISION FOR ABSCESS OF PROSTATE.
Showing skin wound retracted and incision made in levator ani muscle.

front of the colliculus. Anterior to the colliculus the gland is not closely connected to the urethra but posterior to it the connection is very close (Fig. 1646).

Injuries of the Prostate.—The common injuries of the prostate, caused by the passage of metallic instruments, heal promptly if infection does not

spread in the wound; and any treatment that is required is indicated for such complications as abscess of the prostate or cystitis.

Prostatic Infections.—*Acute prostatitis* should be treated by elimination of the cause, emptying the bowel, rest in bed, and hot rectal irrigation. (Cold rectal irrigations are sometimes more comforting.)

Abscess of the prostate, if not tubercular, should be evacuated as soon as the diagnosis is made. The best path of approach is at one side of the median line of the perineum. The patient is placed in the perineal position. By keeping below and to the side of the urethra the urinary canal need not be opened.

FIG. 1648.—OPERATION FOR ABSCESS OF PROSTATE.
Fibers of levator ani retracted to expose prostate.

An incision is made obliquely from the base of the scrotum at the median line outward and backward to a point midway between the tuberosity of the ischium and the anus, on the side on which the swelling is most pronounced (Fig. 1647). The tissues are divided down to the muscles. The prostate is reached by retracting the transverse perineal muscles and splitting the fibers of the levator ani. The rectovesical layer of the pelvic fascia is then incised and the prostate comes into view (Fig. 1648). A small drainage tube should be left in the abscess.

Retention of urine, complicating abscess of the prostate, should be treated by rules already laid down for retention (see page 209). If incision is not practised, the abscess may be expected to rupture into the urethra; less commonly spontaneous rupture occurs through the perineum or in the rectum.

Chronic prostatitis calls first for the relief of any stricture of the urethra which may be present. Pressure upon the prostate in a manner similar to that of massage is the one curative measure of most utility. This is best applied through the rectum. The patient voids urine and stands bent over a table or the back of a chair. The surgeon inserts the rubber covered index-finger into the rectum and presses from behind forward on either side and then in the middle. Rather strong pressure is made against the prostate with but little stroking movement. Pressure is made and then relaxed. Or steady pressure may be made. The operation squeezes out the contents of the prostatic acini and stimulates circulation. It should be applied first laterally and in the middle of the organ. The operation should be continued for about three minutes. Stroking massage may injure the mucous membrane of the rectum or seminal vesicles. After the gland has been subjected to this squeezing the urethra should be washed out with a mild antiseptic solution. Much benefit is commonly secured by this treatment applied once or twice a week in selected cases. Which cases will be benefited cannot often be foretold. It is largely a matter of experiment. Some cases are made worse. The treatment should be continued only in those in which improvement of symptoms is observed.

Another method which has given good results is the dilatation of the prostatic urethra by means of sounds or the deep urethral dilator. This may be carried up to No. 35 F. or 40 F. Such dilatation may be done once a week and later once a month. A sound in the urethra and a finger pressing the prostate from the rectum is also effective.

Several weeks or months are required for the cure of this condition. It is so commonly associated with chronic urethritis of gonorrheal origin, that the prostatitis cannot be said to be cured until the chronic urethritis is cured.

Infiltrations around the prostate also are relieved by the massage pressure above described.

When there is marked congestion of the prostatic urethra a large-sized cold sound may be left in the urethra for five minutes once or twice a week. The local application of silver nitrate solution (2 per cent.) is of value. When the verumontanum is congested touching it with a 20 per cent. silver nitrate solution is effective.

After applying treatment once or twice a week for two or three weeks, it is well to give the patient a rest for a month to observe what has been accomplished.

Cases in which there are symptoms of vesical obstruction are often relieved by dilatation of the prostatic urethra and vesical sphincter. This dilatation should be extreme—No. 35 F. or even 40 F. When dilatation fails to relieve the obstruction, operation for prostatic obstruction is called for.

Intractable cases of chronic prostatitis, after other measures have failed, even though there is no obstruction, are best relieved by prostatectomy, carried out with due regard for preserving the seminal vesicles and ejaculatory ducts.

Tuberculosis of the prostate should be treated by the constitutional measures prescribed for tuberculosis in general (Vol. I, page 276). This is more essential than local treatment. It is capable of curing a large proportion of these cases. Nor need the case be despaired of when the seminal vesicles and other organs are also involved. For pain, suppositories of hyoscyamus or belladonna are useful. Opium may be added in extreme cases.

Local surgical treatment has little to offer. For painful prostate, without sinuses, prostatectomy may be done in selected cases, if the operation can be carried out without opening the urethra. In skillful hands some good

results have been secured. Removal of the prostate for tuberculosis is apt to leave a persisting sinus, communicating with other tuberculous foci or a urinary fistula. Abscess should be treated by the rules already laid down (Vol. I, page 281). A tuberculous abscess which is incised or which ruptures spontaneously results in a sinus which leaves the patient worse than before.

It is the current surgical practice to remove the kidney or epididymis when the primary focus is in one of these organs. This practice represents a measure of desperation, growing out of the fact that proper constitutional treatment can be applied in but a small proportion of cases on account of the wide prevalence of poverty.

Hypertrophy of the Prostate.—The *prevention* of prostatic hypertrophy has made little progress because the cause of the disease is not well enough understood. Too frequent or prolonged congestion of the sexual organs may be regarded as an etiologic factor, for which reason excessive coitus or persistent ungratified sexual excitement should be avoided. Men with enlarged prostate should keep the general health in the best possible condition. Constipation and overdistention of the bladder should be avoided. The urine should be kept unirritating. The conditions which cause arteriosclerosis should be avoided.

The *palliative* measures consist in treating acute or chronic prostatitis which are often the underlying cause. A certain proportion of chronic cases yields to prostatic pressure, massage, and dilatation of the prostatic urethra and vesical sphincter. The treatment by dilatation, in some cases produces congestion and an actual worsening of the condition, and should be confined to experienced hands. It is best practised with the deep urethral dilator in preference to sounds. The dilatation should be carried up to the point of considerable resistance, which will be met usually short of 32 F. At each treatment one or two points of dilatation should be gained, until 40 or 42 F. is reached. Not more than two or three minutes of time should be consumed in actual dilatation. This treatment is to be considered only in cases of prostate which is not greatly enlarged, or cases which for some reason cannot be subjected to operation, or cases in which the obstruction is due to temporary congestion.

Treatment by *catheterization* was once much practised, but the inevitable infection of the urinary tract has shown that a persistence in the practice is more dangerous than radical operation. The urine may be drawn by the surgeon for a period while the case is being studied. Often the congestion which has caused the obstruction subsides under this treatment. Hexamethylenamin should be administered in amounts of about 0.5 Gm. (7½ grains) 4 times daily while the catheter is being used, and if any sign of cystitis appears the bladder should be irrigated once daily (see Retention, page 209). Catheterization has been practised by the patient himself in some cases for many years without serious infection; but as a rule the use of the catheter by the patient is soon followed by cystitis and its complications.

Operative Treatment of Prostatic Hypertrophy.—Operation is called for in cases of prostatic obstruction in which catheterization and dilatation fail to give relief. These measures may be given a trial in some cases. Catheterization, as a preparative treatment, is of value in relieving the prostatic congestion which is incidental to the pressure of retention. Usually one or two catheterizations will do all that can be expected in the direction of relieving the congestion of the prostate. Cystitis is not an indication for operation, as it may be treated and cured during the application of palliative measures. Patients, who have had retention with prolonged obstructive pressure upon the urinary organs, should positively not have their obstruction completely

relieved at one operation, as they are prone to develop fatal congestion of the kidneys. Such cases are better treated by catheterization until the bladder has become accustomed to be relieved of pressure. Cases in which persistent hemorrhage renders catheterization difficult should be treated by operation.

The cases in which there is an undoubted obstruction which is organic and not due to congestion, should be treated by operation, unless there is some positive contraindication.

Perineal or *suprapubic cystotomy*, with the placing of a tube for constant drainage, is found in some cases of soft hypertrophy to be all that is required to give relief. As a preliminary step it is of value in cases with cystitis in order to secure a cure of the infection before proceeding with prostatectomy as a second step.

Galvanocaustic prostatotomy (Bottini) is accomplished by a special instrument, having a blade which can be heated by electricity while the rest of the instrument is kept cool by a current of water. Blades of different height are

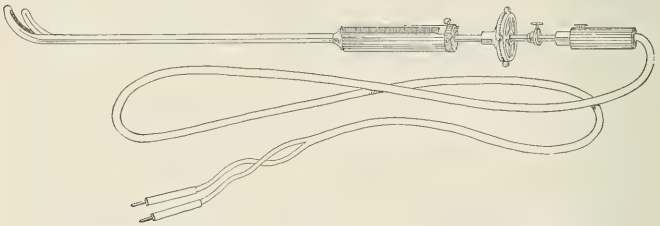


FIG. 1649.—PROSTATOTOMY APPARATUS FOR DIVIDING OBSTRUCTION BY MEANS OF THE GALVANOCAUTERY.

used, depending upon the size of the prostate (Fig. 1649). It is customary to draw the blade heated to a white heat, through the median line of the prostate, and then to make a cut on either side, backward and outward into the lateral lobes. The length of the incisions should be the same as the length of the prostate which should be determined by careful preliminary examinations. Blades from 1 to 1.6 cm. (½ inch) are used. The incision is usually from 2.5 to 4 cm. (1 to 1½ inches) long. The blade should be heated and drawn slowly through the tissue. Some operators prefer to do a perineal urethrotomy and introduce the instrument through the wound.

The operation can be done under cocain anesthesia (4 per cent. solution, washed out before operating). Often the patient can void urine, after the operation. If he cannot, a fixed catheter should be placed *in situ*, or the patient should be catheterized at regular intervals. Sloughs come away and are voided with urine about a week after the operation.

The results of the operation are very variable and cannot be predicted. The statistics of Freudenberg show 85 per cent. good results, 55 per cent. cured, 30 per cent. improved, 8 per cent. bad results, and 7 per cent. of deaths. Young's experience was about the same. The hazards of the operation seem to be greater than for prostatectomy. Most surgeons who employed it at first have abandoned it. Its only field is probably in small sclerotic prostates and in bar formation at the outlet of the bladder.

Prostatectomy is *indicated* in most cases in which operative relief for enlarged prostate is called for. It may be said that the operation is indicated

in almost any case in which prostatotomy is indicated, the latter operation having fallen into disuse since the perfection of the former.

In general, prostatectomy for hypertrophied prostate is to be done in cases in which urine can be voided only through the catheter, in cases in which periodic congestion of an enlarged prostate precipitates attacks of complete obstruction, in cases in which irritability and painful urination cannot be relieved by local and internal treatment, in cases in which failure to empty the bladder keeps up a constant irritation, and in cases of prostatic obstruction in which tentative and palliative measures have failed.

Prostatectomy cannot be expected to yield good results in cases with general infection of the urinary organs, advanced general debility, renal insufficiency, or pronounced arteriosclerosis. In diabetes the mortality of operation is very high. These conditions may be regarded as contraindications to the operation, except in the most skillful hands.

The greater the quantity of residual urine (atony being excluded) the more strongly is prostatectomy indicated, irrespective of the size of the prostate. Patients having only 60 or 90 c.c. (2 or 3 ounces) of residual urine and only slight symptoms usually do not require operation.

In the *preparation for operation*, it is possible to relieve the patient of the chief disturbances caused by the obstruction. This is the important feature of treatment, and is capable of eliminating the chief hazards of operation. These patients have suffered from prolonged damming back of urine, with its serious consequences to the kidneys and general system. This can be relieved by placing a permanent catheter in the urethra or by a suprapubic catheter introduced through a canula and the latter removed. By giving the patient, who has suffered from prolonged obstruction, the benefit of permanent drainage, he may be helped to recover from serious consequences of the prostatic hypertrophy before prostatectomy is attempted. He can be induced to drink large quantities of water, which previously he was unwilling to do. His contracted circulatory system is filled, the body fluids increased, sleep secured, and a decided general improvement of all the bodily functions obtained. Under this treatment the specific gravity of the urine falls. After it has reached a minimum it then rises. This reaction indicates restored metabolism, increase of food, and improved kidney function. Operation should be deferred until this reaction is secured. From several days to several weeks may be required.

The benefits which follow drainage of the bladder in these cases are very striking. Rarely should prostatectomy be done until the patient has had this bladder drainage for several days. The removal of an obstructing prostate before the patient has had the benefit of relief of pressure in the bladder and kidneys is fraught with great risk. The mortality is very high; but prostatectomy after a few days of bladder drainage is not a dangerous operation.

The *choice of operation* is largely a matter of adaptability of the surgeon. Some surgeons are more skilled in the perineal route, others in the suprapubic route. There is a choice, and it is a mistake to develop a dogmatic preference for either. The perineal operation is somewhat more difficult than the suprapubic; it gives better drainage; and is followed by a shorter convalescence. The suprapubic operation is generally to be preferred in cases in which the bladder contains a large stone; in cases with a pronounced intravesical projection; in cases in which the finger in the rectum cannot reach the upper border of the gland which does not protrude strongly into the rectum; in cases in which there is a large amount of residual urine and in which a catheter cannot be introduced or does not functionate well; and in

cases in which the hypertrophy is of the massive adenomatous type. Local anesthesia is much easier in the suprapubic operation; and the postoperative treatment is more simple. There seems to be less liability to complicating epididymitis after the higher operation.

The cystoscope is a valuable aid in determining the route of operation. The mortality of the two operations is about the same. Some surgeons report a series of 100 prostatectomies without a death. The mortality in all hands is decidedly larger than might be inferred from the statistics.

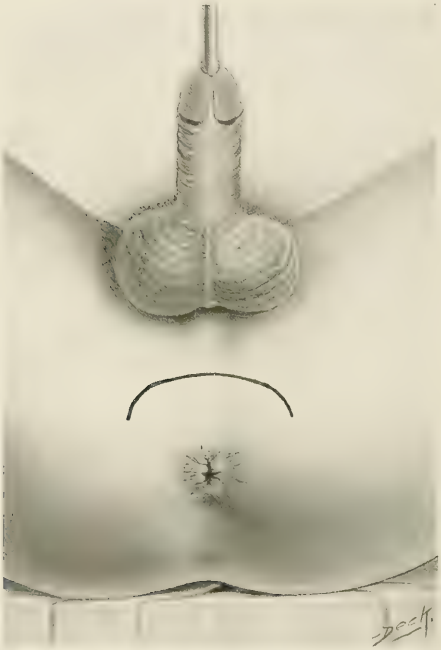


FIG. 1650.—CURVED, TRANSVERSE INCISION FOR PERINEAL PROSTATECTOMY.

The *anesthetic* to be employed in prostatectomy is important. It should be the least depressing, administered in the smallest possible amount, and for the shortest possible time. Ether and oxygen are at present most in favor. Suprapubic prostatectomy may be done under local anesthesia with the addition of a rectal suppository of hyoscyamus and morphin. Perineal prostatectomy also may be done with local anesthesia, but less easily than the suprapubic operation.

Perineal prostatectomy is done with the patient in the extreme perineal position, the perineum not only being prominently presented at the foot of the table but the pelvis should be elevated well above the table level by means

of a sand-bag. A soft catheter should be inserted to render the urethra easily identified. A transverse curved incision with its concavity toward the rectum is used. The bulb of the corpus cavernosum should be at the meridian of the incision. This is about 5 cm. (2 inches) anterior to the anus. The arms of the incision should curve outward and backward toward the tuberosities of the ischium for about 5 cm. (2 inches) on either side of the median line (Fig. 1650). The skin and fat are divided, and then by blunt dissection, directed toward the prostate, the space on either side of the central tendon is opened as far as the triangular ligament. The transverse perinei muscles are retracted forward and the levator ani backward (Fig. 1651).

The central tendon is divided close to the bulb, bringing into view the recto-urethralis muscle, covering the urethra. The latter muscle should be divided also transversely. This muscle draws the rectum forward in front

FIG. 1651.—PERINEAL PROSTATECTOMY.
The superficial structures are retracted exposing bulb and central tendon.

of the prostate, and its division permits backward retraction of the rectum and exposure of the membranous urethra. By retracting the divided muscles backward along with the rectum, the capsule of the prostate is exposed on its posterior surface. It is often necessary to divide the dense fascia between the rectum and prostate in order to reach the back of the gland. When this is done and a broad retractor introduced the lower, and even the posterior surface of the prostate is exposed. Lateral retractors aid in the exposure.

The capsule of the prostate is divided transversely and the inferior surface of the gland structure exposed. Inserting the index-finger in this opening the surgeon proceeds to enucleate the gland, working from below upward. First the lateral lobes and then the middle lobe are removed.

The lateral lobe is separated by finding the line of cleavage between it and the lateral capsule and the posterior part of the gland. That part of the lateral lobe lying above the urethra is enucleated by sweeping the finger forward and carefully dissecting it from the urethra. The finger then passes back and separates the gland from the base of the bladder, while the surgeon keeps in mind the seminal vesicles and the duct. The lateral lobes should

each be removed separately, leaving uninjured the spermatic ducts which traverse the prostate between the two lobes. By separating the two lobes the ducts are left uninjured (Fig. 1652).

The gland is removed piece by piece. Care should be taken to keep away from the rectum and to avoid tearing the mucous membrane of the bladder or urethra. In many cases the urethra must be opened. The most commonly performed operations open it as a preliminary step. When this is done the urethra is incised just in front of the prostate. Through this opening a tractor (Fig. 1653) may be introduced into the bladder to pull the prostate forward. H. H. Young devised a special instrument for this purpose.

If a tractor is not employed, long forceps are often of service to grasp the lobule which is being enucleated. Suprapubic pressure with the other hand or a finger in the rectum may help press the prostate toward the wound. When the urethra is opened, a finger in the bladder serves to press down the projecting middle lobe and facilitate removing it.

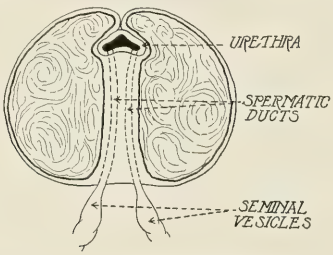


FIG. 1652.—SECTION OF PROSTATE.
Showing course of spermatic ducts through prostate and into urethra.

In enucleating the lateral lobes it will often be found necessary to use the scissors to cut the firm adhesions at the apex of each lobe. The middle lobe has the urethra lying in front of it and the ejaculatory ducts behind it, and after it has been shelled out of its pocket a median cavity is left communicating with the two lateral cavities.

If there is an opening in the urethra the finger should be passed into the bladder to search for any nodules which may remain. All nodules should be removed if adjacent to the bladder or urethra. Any inflammatory stricture around the vesical orifice should be dilated. Stone should be sought for.

Hemorrhage is usually slight, and is controlled by the dressing. A finger should be inserted in the rectum to determine if the bowel has been wounded. If it has, the wound should be sutured in at least two layers. The levator ani muscle should be sutured at the median line in front of the rectum. The cavity from which the prostate was removed should be packed with gauze or wicking and the ends brought out at the middle of the wound. If there is a tendency to bleed, a packing of gauze impregnated with kephalin is useful.

If the urethra has been opened, a rubber tube should be placed through the opening in the bladder as for perineal drainage (see Perineal Cystotomy, page 217). The bladder should be washed out and the tube fastened to the

skin by a suture. The gauze drains should emerge at the side of the tube. The outer ends of the wound should be sutured.

Some surgeons instead of incising the capsule transversely on the lower surface of the gland make a median incision. H. H. Young made an incision through the capsule on each side of the median line for almost the entire length of the posterior surface, about 1.7 cm. apart. The bridge of tissue between these incisions contains the ejaculatory ducts and the floor of the urethra. The enucleation proceeds through the two openings.

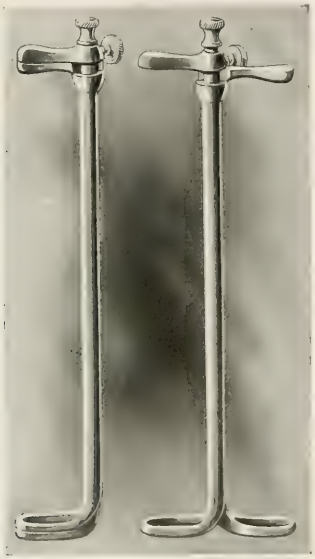


FIG. 1653.—PROSTATIC TRACTOR OF YOUNG.
Closed (ready for introduction) and open (ready for traction).

Suprapubic prostatectomy is to be preferred in the great majority of cases. Many surgeons do this operation in all cases. It is surely an easier operation and threatens the patient with fewer complications than the perineal operation.

Briefly the advantages of the suprapubic operation are: (1) the approach is practically bloodless; (2) enucleation may be done by the aid of sight or by touch alone; (3) at any time in the operation the field can be greatly enlarged if necessary; (4) stone or other disease of the bladder is most easily dealt with; (5) the prostate is more accessible and can be brought up still closer to the operator by digital pressure in the rectum without the use of instruments; (6) the internal sphincter and the compressor urethræ muscles may be spared and incontinence more easily avoided than in the perineal operation; (7) venereal potency is no more apt to be lost than after the perineal

operation, although sterility is, perhaps, more commonly caused by the suprapubic operation; (8) if a catheter is used in the urethra, persistence of a fistula is less frequent; (9) the operation on the whole is easier and the complications fewer than in the perineal operation; and (10) the operation may be done under local anesthesia and as a two-stage procedure to a better advantage.

The preparation is the same as for perineal prostatectomy and for cystotomy. A suprapubic cystotomy, under local anesthesia, is first performed (see page 214).

To perform the operation with the least amount of shock should receive especial consideration. The patient should be given an injection of morphin and scopolamin an hour before operation. The operation should begin with irrigation of the bladder. The catheter is left in the bladder. Ninety cubic centimeters (3 ounces) of a 5 per cent. solution of alypin or similar local anes-

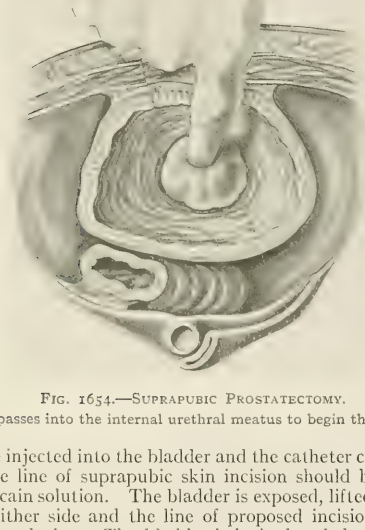


FIG. 1654.—SUPRAPUBIC PROSTATECTOMY.
The finger passes into the internal urethral meatus to begin the enucleation.

thetic should be injected into the bladder and the catheter clamped to prevent its escape. The line of suprapubic skin incision should be infiltrated with 1 per cent. novocain solution. The bladder is exposed, lifted up with tenacula or sutures on either side and the line of proposed incision infiltrated with 1 : 400 novocain solution. The bladder is incised and the prostate exposed. The mucous membrane overlying the prostate is then infiltrated with 1 : 400 novocain and deep injections are made to reach the capsule. The enucleation is then proceeded with as described below. If pain is complained of a few inhalations of nitrous oxid and oxygen are given.

Anesthetization and suprapubic cystotomy having painlessly exposed the prostate, an assistant lifts up the prostate by pressure with the fist against the perineum or the surgeon passes the other finger in the rectum. Through the suprapubic opening, the surgeon passes the index-finger into

the urethral meatus in the bladder, and breaks through the mucous membrane of the roof of the prostatic urethra with the tip of the finger inserted through the meatus (Fig. 1654). At this point the lobes, having enveloped the urethra, meet in the anterior median line. The finger passes forward and upward into this line of cleavage; and the apex of the gland, first on one side and then on the other, is freed from the urethra and triangular ligament. Pains should be taken to spare the urethra as much as possible. If the surgeon passes a finger of the other hand in the rectum and lifts up the prostate, he may manipulate the gland to the best advantage (Fig. 1655).

FIG. 1655.—SUPRAPUBIC PROSTATECTOMY.

The index finger of the right hand has been passed through the suprapubic wound and into the prostatic urethra. Enucleation is begun at the extreme front of the prostate. The finger breaks through the lateral inferior wall of the urethra. The left index finger in the rectum lifts up the gland.

The finger is then swept laterally, following the line of cleavage. As the gland is separated from the base of the bladder and as the finger passes to its posterior aspect, it is well to split the gland in two, taking out each half separately, and thus better preserving from injury the spermatic ducts. It is possible to remove the gland in one mass, but the ducts are apt to be sacrificed in so doing.

After the anterior and later aspects of the gland have been freed, the finger is passed between the prostate and the rectum and the gland enucleated and turned back into the bladder. This strips the mucous membrane away from

its posterior aspect. All pieces of prostatic tissue should be removed. Forceps are used to withdraw the gland and its fragments.

Instead of approaching the gland through the roof of the urethra, a common practice is to incise the mucous membrane of the bladder over the most prominent part of the prostate. This incision damages the internal sphincter, veins are cut, and the ejaculatory ducts are apt to be injured.

Clots should be washed out. Persistent bleeding usually comes from the torn edges of bladder wall. If it continues a speculum should be inserted and the bleeding vessel caught with a clamp or a packing introduced for a short period or the actual cautery applied. Uncontrolled oozing may require packing. This is best done by passing a good-sized rubber catheter to the bladder, and then continuing it until it emerges at the suprapubic opening.

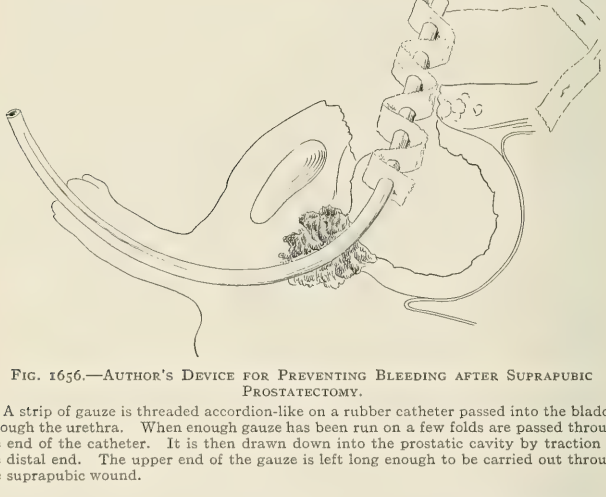


FIG. 1656.—AUTHOR'S DEVICE FOR PREVENTING BLEEDING AFTER SUPRAPUBIC PROSTATECTOMY.

A strip of gauze is threaded accordion-like on a rubber catheter passed into the bladder through the urethra. When enough gauze has been run on a few folds are passed through the end of the catheter. It is then drawn down into the prostatic cavity by traction on the distal end. The upper end of the gauze is left long enough to be carried out through the suprapubic wound.

A piece of gauze 2.5 cm. (1 inch) wide and 30 cm. (12 inches) long is perforated with holes about 4 cm. (1½ inches) apart. These holes may be made with a sound a size larger than the catheter. The perforated strip of gauze is then threaded onto the catheter; folding it back and forth and pressing it down into the bladder as it slides over the catheter (Fig. 1656). When the end has been reached a slit is cut in the end of the catheter and one or two folds of the gauze drawn through it (Fig. 1657). When this catheter is drawn down it carries with it the gauze folded down into the wound cavity (Fig. 1658). Traction on the penile end may be made by connecting the end of the catheter by a thin rubber elastic to adhesive plaster on the side of the thigh. Such a packing need not remain in longer than twenty-four hours It is easily removed by pushing up the catheter to the suprapubic wound. This may also be used for the treatment of secondary hemorrhage which comes on

after twelve or twenty-four hours or a week. This is a device which I have found practical and satisfactory. It need be used only in bleeding cases.

The cavity left after removal of the prostate rapidly contracts because of the elastic nature of the prostatic sheath and the pressure of the surrounding viscera. Bleeding is usually checked by a few seconds of hot irrigation or tampon pressure. A rubber drainage tube 2 cm. (¾ inch) in diameter, is introduced into the bladder for a distance of not more than 2.5 cm. (1 inch). The tube should not enter the prostatic cavity. It should be fixed in the upper part of the bladder wound by a purse-string suture, and the lower part of the wound should be closed. If a gauze packing has been used, the end may be brought out through the tube. The wound in the abdominal wall is sutured with silkworm-gut, a small drain being left in the prevesical space, as for suprapubic cystotomy. This suprapubic drainage of the bladder is a most important step in the operation.

Instead of a purse-string suture, it is quite as satisfactory to place a suture in the bladder wall on either side of the incision before the bladder is opened. These sutures serve as retractors during the operation; and may be tied around the tube at the end.

Some surgeons prefer to leave a urethral catheter in the bladder, and pack the cavity from which the prostate came with narrow strips of gauze. This presses the mucous membrane against the raw surface and prevents bleeding (Fig. 1659). This catheter should not be depended upon to carry off the urine, but the suprapubic tube should also be inserted. The urethral catheter is apt to excite infection and is best not used.

FIG. 1657.—PROSTATIC PACKING.

Showing method of drawing gauze through the end of the catheter.

The bladder should be irrigated through the suprapubic tube every day with warm saline solution. This is done by inserting the nozzle of the irrigator, but care should be taken not to disturb the adhesions which are developing in the collapsed cavity. The tube should be kept free from clots. In from three to five days the tube may be removed. The bladder should continue to be irrigated through the suprapubic opening at least once daily. Irrigation should continue until the fluid returns clear. When urine is passed by the natural route the daily irrigations may be discontinued. This should occur in about two weeks.

Some surgeons apply continuous suprapubic irrigation with simple sterile water in connection with suprapubic aspiration drainage. This should be arranged so as to keep the dressings dry. It need not be continued longer than a week. At the end of that time the bladder may be washed out daily through the urethra.

It sometimes happens that the torn prostatic urethra heals together and produces obstruction. When the wound flaps are large or the damage to the urethra has been great this accident may be prevented by leaving a permanent catheter in the urethra, the tip just presenting in the bladder. Secondary hemorrhage or persistent oozing call for reopening the suprapubic wound. Usually the best remedy for bleeding is free drainage through the big tube, thus securing collapse of the cavity. Tamponade may rarely be indicated. It is possible to control bleeding by passing a long needle through the peri-

neum, and tying a ligature over a rubber tube on the perineum. The ligature catches the mucous membrane in the bladder.

The patient should be given a urinary antiseptic to prevent infection (see page 141). To absorb the urine that flows from the large suprapubic tube a copious gauze dressing may be used. By changing this frequently the bed is kept dry. Irrigation through the large tube is simple. On the second or third day if there is no bleeding or other complications, the large tube may be removed and replaced by a smaller tube or a catheter having a bulb at the end. If the healing continues without complications this smaller tube may be removed in four or five days. The urine which now flows from the sinus may be collected in the frequently changed gauze dressing or by one of the receptacles made for that purpose which fit over the sinus and keep the patient dry (Fig. 1660).

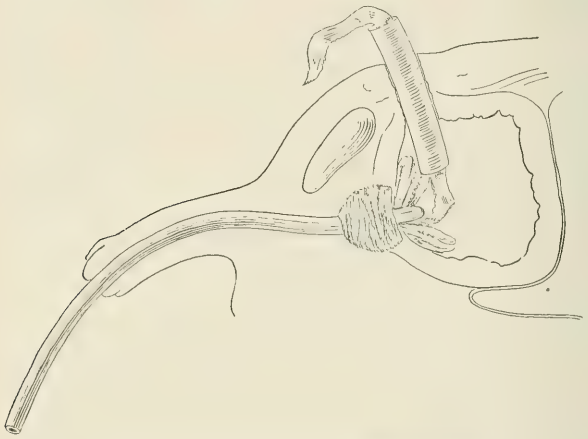


Fig. 1658.—Device for Packing Prostatic Cavity.

The catheter is drawn down, folding the gauze into the cavity. One end of the gauze is brought out through a tube in the suprapubic wound. By passing a very short loop through the end of the catheter, it can be disengaged by pulling upon the suprapubic drainage strip.

The suprapubic wound heals in from one to six weeks, usually it may be expected to heal inside of three weeks. Usually urine will begin to pass through the urethra during the second week after the operation. By the end of two or three weeks the patient should be found to have control of the urine. As the fistula contracts, the amount of urine passed by the urethra increases. The operation, if carefully carried out need not interfere with the function of the ejaculatory ducts, and the sexual potency of the patient is not diminished. Often the operation increases the sexual abilities.

French surgeons apply a large tubular suprapubic drain for about ten days. A retention catheter is then placed in the urethra and left for there days. The suprapubic wound is then closed by suture and the catheter left in the urethra for eight days longer. At the end of three weeks after the operation the sutures are removed and the catheter is discontinued. If the cys-

titis does not clear up in a few days irrigation with a silver solution will promptly cure it.

Suprapubic prostatectomy in two stages was recommended by H. Lilienthal (N. Y. Med. Jour., June 18, 1910) and P. M. Pilcher (Am. Jour. of Surg., June, 1912) in cases with a large amount of residual urine, in which a catheter

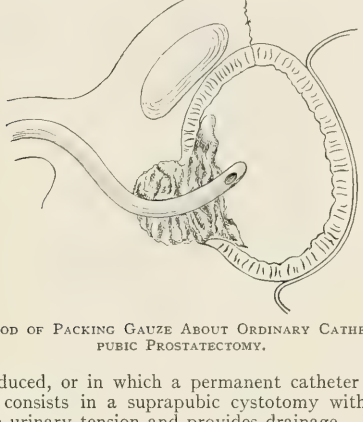


FIG. 1659.—METHOD OF PACKING GAUZE ABOUT ORDINARY CATHETER AFTER SUPRAPUBIC PROSTATECTOMY.

cannot be introduced, or in which a permanent catheter is not effective. The first stage consists in a suprapubic cystotomy with tube drainage. This relieves the urinary tension and provides drainage. It is done under local anesthesia. The patient is kept in bed two or three days and is then allowed up. The prostatectomy is done when the condition of the

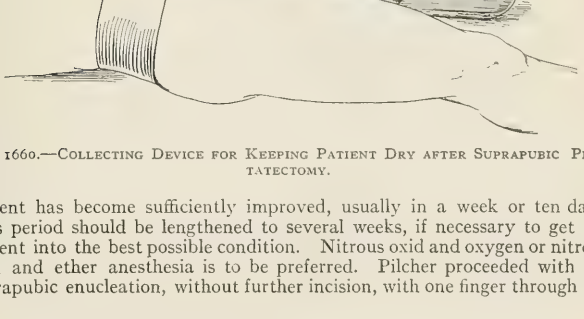


FIG. 1660.—COLLECTING DEVICE FOR KEEPING PATIENT DRY AFTER SUPRAPUBIC PROSTATECTOMY.

patient has become sufficiently improved, usually in a week or ten days. This period should be lengthened to several weeks, if necessary to get the patient into the best possible condition. Nitrous oxid and oxygen or nitrous oxid and ether anesthesia is to be preferred. Pilcher proceeded with the suprapubic enucleation, without further incision, with one finger through the

drainage opening and the finger of the other hand in the rectum. If necessary the opening may be enlarged. The mucous membrane at the vesicle side of the sphincter is torn through with the tip of the finger. If there is marked enlargement of the middle lobe the finger is inserted into the urethra and the mucous membrane torn through. This two-stage principle is one of the most valuable features of the modern operation. It saves lives which would be lost by a one-stage operation.

In performing the suprapubic cystotomy, a retention suture of wellchromicized catgut is placed on either side of the proposed bladder incision. After the bladder has been washed out and emptied of fluid by the urethral catheter, it is incised between the sutures. This incision should be near the peritoneal reflection. The finger then examines the interior of the bladder. If a stone is present, it should be removed. A catheter with a bulbous enlargement or a simple drainage tube should then be inserted. This is held

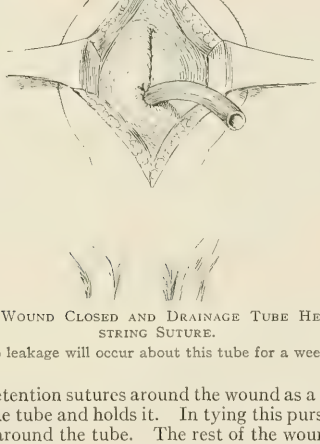


FIG. 1661.—BLADDER WOUND CLOSED AND DRAINAGE TUBE HELD BY TIGHT PURSE-STRING SUTURE.

No leakage will occur about this tube for a week.

by continuing the retention sutures around the wound as a purse-string, which is tied down upon the tube and holds it. In tying this purse-string the wound should be inverted around the tube. The rest of the wound is then closed as though it were permanently. No leakage will occur about this tube for a week (Fig. 1661).

The second stage of the operation should be undertaken when functional tests of the kidneys satisfy the surgeon that the operation may be done safely. If the skin has been sewed with silk, and the suture left in place, after the tube is removed and the finger inserted into the bladder, the primary wound will not break open during the enucleation. The gloved hand should be used. The method employed by P. M. Pilcher, whereby one index-finger passes through the suprapubic opening and the index-finger of the other hand in the rectum lifts up the prostate, is most effective.

Prostatic bars, in which there is an obstructing projection at the urethral orifice without general hypertrophy of the prostate, are best treated by removal of the small median mass. The lesion is discovered by the cystoscope. It

is easily removed through a suprapubic opening in the bladder. H. H. Young devised a special punch for cutting these bars, which permits operation wholly through the urethra. A catheter coated with a thickness of 1 or 2 mm. of kephalin and inserted prevents bleeding. Bleeding following the operation can be stopped by injecting adrenalin solution into the bladder.

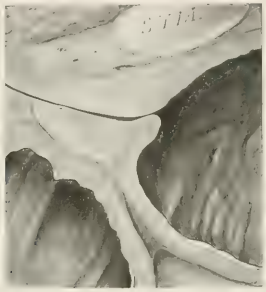


FIG. 1662.—PROSTATIC OBSTRUCTION TO BE TREATED BY THE PUNCH OPERATION OF YOUNG.

The *punch operation*, Young has shown, is of especial value in desperate cases of enlarged prostate which cannot be subjected to prostatectomy (Annals of Surg., May, 1917). Intra-urethral applications of radium are combined with this treatment. The punch operation is carried out with the apparatus of Young in cases of obstructing bar or enlarged prostate (Fig. 1662). The punch instrument is inserted past the obstruction. This allows

FIG. 1663.—THE PUNCH INSTRUMENT OF YOUNG IS PASSED INTO THE BLADDER.

the fluid to escape and shows that the instrument has entered the bladder (Fig. 1663). The cutting tube is then pressed home and the obstruction engaged by the instrument (Fig. 1664). The bar is completely cut through by the instrument (Fig. 1665). This leaves a raw wound on the floor of the internal meatus (Fig. 1666). A catheter coated with kephalin is inserted and no bleeding need be expected.

These operations may be done under local anesthesia with 4 per cent.

novocain injected into the deep urethra and a suppository of opium and atropin in the rectum. Several cuts around the internal meatus may be made. Young in some cases makes as many as eight cuts.

In the desperate cases radium, applied through a catheter, passed down to the prostatic urethra, causes shrinkage of the gland. After the condition of the patient has been improved the punch operation may be done.

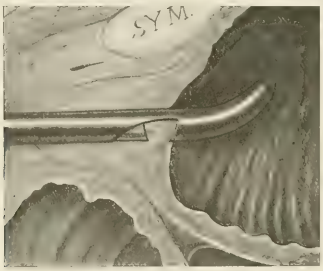


Fig. 1664.—The Cutting Tube is Pressed in and the Obstruction Engaged by the Instrument of Young.

The objection to this operation is that it requires a special instrument. In most cases a more satisfactory operation can be done through a suprapubic opening under the direct vision of the operator.

Fibrous contracture of the urethral orifice, causing obstruction should be regarded as stricture and treated as such. The operation is best done through a small median perineal incision. The stricture may be divided with the cautery knife. I have treated some of these cases by simple dila-

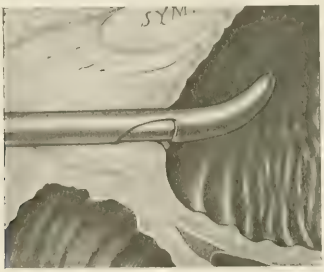


Fig. 1665.—The Cutting Tube Completes the Excision of the Obstructing Bar.

tation with a uterine dilator introduced through the perineal wound. A drainage tube should be left in the bladder for a few days.

Tumors of the Prostate.—*Benign tumors*, such as *fibroma* and *myoma*, require the same treatment as hypertrophy of the prostate.

Malignant tumors are usually carcinomata. *Carcinoma* may be prevented by the same precautions as are applied for the prevention of prostatic hyper-

trophy and posterior urethritis locally and by the general measures for preventing cancer (see Cancer, Vol. I, page 327). A very large proportion of enlargements of the prostate in old men are malignant. Curative treatment requires total removal of the prostate. The operation should be more radical than that for simple hypertrophy. The perineal route is best adapted to most cases. The membranous urethra should be amputated, the prostate grasped by strong forceps, and the whole gland enucleated from before backward as a tumor. Any involvement of the floor of the bladder, or even close approach of the disease to the bladder, calls for removal of a safe amount of bladder wall. In the treatment of this condition there is an opportunity for the display of surgical talent. The object of the operation should be to remove every bit of the carcinoma. The surgeon should be prepared to resect bladder or rectum or both. The operation is not curative unless thorough.

Prostatectomy for cancer differs from the operation for hypertrophy in many respects. No line of cleavage can be sought for, as the excision should be wholly external to the gland. Enucleation must be done by cutting rather than by force. The best access will be secured by using both the perineal and suprapubic routes. Through the perineal approach the prostate is separated from the rectum. If the rectum is involved in the disease a free resection of the bowel is practised. This perineal operation may be done as a preliminary procedure and the enucleation from above performed several days later.

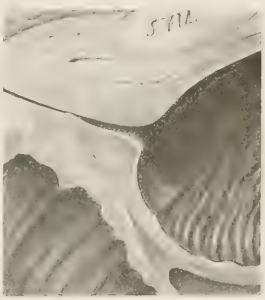


FIG. 1666.—RESULT AFTER PUNCH OPERATION HAS REMOVED OBSTRUCTING BAR.

The suprapubic operation proceeds as for enucleation for hypertrophy. If the bladder wall is not involved it is reflected aside and the prostate cut out with scissors and cautery. The tendency of the disease is to invade the floor of the bladder; and if this has occurred, as much of the bladder floor as is necessary should be resected with the gland. The ureters should not be spared if they are near the disease. If the ureters must be cut, it is well to do a lumbar nephrostomy for urinary drainage. The ureters should then be implanted in the sound part of the bladder. With lumbar drainage the surgeon may proceed leisurely with reconstruction of the bladder and its ureteral and urethral connections. The amputated urethra should be sewed to the repaired bladder.

Throughout this operation the actual cautery should be freely used for dividing tissue and for cauterizing the wound (see Cautery Treatment of Cancer, as described for cancer of the uterus, page 422). The operation may be done in several stages. The extent of the growth should have been well predetermined by cystoscopic and rectal examinations.

If both the rectum and bladder are involved, perineal dissection with resection of the rectum is indicated. This may wisely be preceded by inguinal colostomy which gives an opportunity to determine the presence or absence of abdominal metastases which would influence the course of further procedures. Bladder resection should be preceded by lumbar nephrostomy or ureterostomy. The surgeon, having disposed of the rectum, has the whole lower pelvis to command, where there are no other structures which he need spare.

Operations for cancer of the prostate have usually been followed by recurrence. Later reports show that 50 per cent. of cases operated upon are being cured. Some surgeons report as high as 60 per cent. of cures. The disease is by no means as hopeless as it was formerly supposed to be. It progresses slowly, and if early diagnosis is made by routine rectal examinations most cases may be cured. The disease remains long confined within the capsule.

Incontinence may be prevented by preserving the anterior layer of the transverse pelvoprostatic fascia. The nerves and vessels of the triangular ligament should be spared. After removing the bladder wall adjacent to the prostate, the bladder should be sewed to the membranous urethra to prevent incontinence.

In *sarcoma* of the prostate a wide enucleation of the gland offers the only hope. If adjacent structures are involved in the disease the operation must be complete to effect a cure. Even under the best conditions recurrence is to be expected.

Cysts of the prostate should be treated the same as cysts of other glands.

The *palliative treatment* in cases which cannot be cured consists first in relieving obstruction. The passage of a good-sized sound may relieve retention. Habitual catheterization may become necessary. Cystotomy and the establishment of a permanent fistula is the last resort.

Prostatic Stone.—True prostatic calculus (formed in the substance of the gland) is best approached by the perineal route. The gland should be exposed as for perineal prostatectomy. It should be incised upon a staff or a prostatic tractor, and the stone or stones scooped out. The cavity should be drained till granulations form. When stone has developed in the hypertrophied prostate, prostatectomy is to be preferred to lithotomy.

Urinary stone which has become lodged or formed in the prostatic urethra or stone which has become partly enveloped in the prostate may be removed by the suprapubic route.

Irritable Prostate and Prostatorrhea.—These conditions require the treatment already described for chronic prostatitis (page 229).

Atrophy of Prostate.—This condition usually requires no treatment. There are cases, however, in which the atrophy so narrows and distorts the prostatic urethra as to cause urinary obstruction, and demand operative relief. Prostatectomy for atrophy is indicated, if simple dilatation of the passage does not effect a cure.

THE PENIS AND URETHRA

Anatomy.—The penis is a pendulous organ made up largely of erectile tissue and traversed by the urethra. It is divided into root, body, and head. The skin covering the organ is loose and distensible, and is continued in a double fold over the head as the *prepuce.* In the median line on the posterior surface is a cord called the *frenum.* The erectile tissue is contained in the two *corpora cavernosa* and the *corpus spongiosum.*

The cavernous bodies form nearly half of the bulk of the organ. They are two cylinders lying side by side. The spongy body lies in the groove posterior to the others and parallel with them. It begins posteriorly at the triangular ligament in an enlargement called the *bulb.* Its lower end expands into the glans.

The *root* is attached to the rami of the pubis by the crura which are the posterior extremities of the cavernous bodies. A suspensory ligament connects it to the symphysis pubis.

The *glans,* or head, has at its summit the opening of the urethra, the *external urinary meatus.* It fits over the lower ends of the cavernous bodies. The projecting edge of the base of the glans is the *corona,* above which is the *neck.* The anterior surface of the body is called the *dorsum,* so named out of respect to the erect state of the organ.

The bulb of the spongy body is embraced by the accelerator urinæ muscle. The *urethra* enters the bulb posteriorly and runs forward in the middle of the spongy body (Fig. 1667).

The *urethra* in the male is divided in three parts: prostatic, membranous, and penile. It extends from the bladder to the external urinary meatus.

The *prostatic urethra* is 3.2 cm. (1¼ inches) long. On its floor is the *verumontanum*, on either side of which are the *prostatic sinuses* in which open the *prostatic ducts*. At the anterior part of the verumontanum is a depression, the *sinus pocularis*, upon the edges of which open the *ejaculatory ducts*. The caliber of the prostatic urethra is 30 to 45 F.

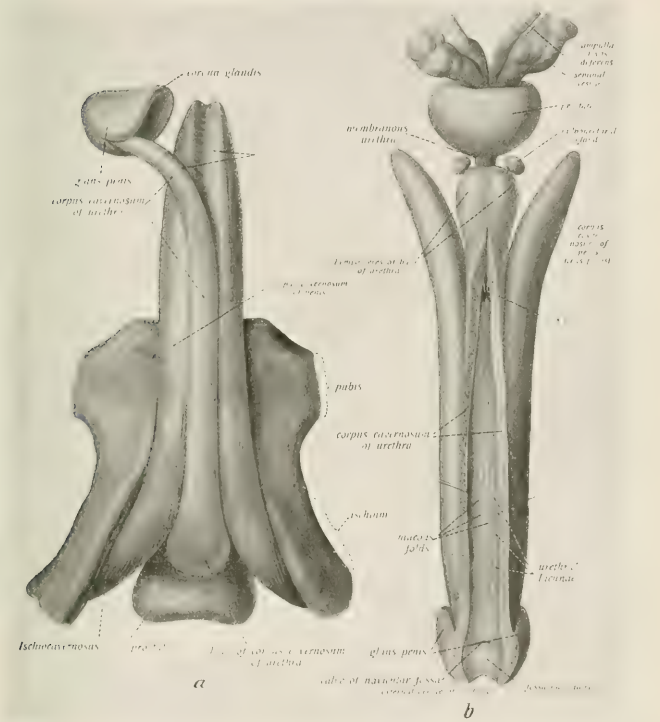


FIG. 1667.—ANATOMY OF PENIS. (*Sobotta and McMurrich.*)

a, The corpora cavernosa of the penis: The glans penis and the anterior part of the corpus cavernosum of the urethra have been drawn aside. * = Points which are in contact when the parts are in their natural position. *b*, The male urethra with the corpora cavernosa of the penis, the bulbo-urethral glands and the prostate: The corpus cavernosum of the urethra has been opened by a longitudinal incision in its midventral line. ** = Sounds in the orifices of the bulbo-urethral glands.

The *membranous urethra* lies between the apex of the prostate and the bulb of the spongy body. It is about 2 cm. (¾ inch) long It lies between the layers of the triangular ligament and is embraced by the compressor urethræ muscle. Its caliber is about 27 F.

The *penile urethra* is contained in the corpus spongiosum, and extends from the anterior leaf of the triangular ligament to the external urinary meatus. It is 15 cm. (6 inches)

long (Fig. 1668). The bulbous portion of the urethra is larger than the distal part; it has a caliber of 33 to 36 F. An expansion just above the external meatus, called the fossa navicularis, has a calibre of 30 to 33 F. The intervening part of the penile urethra has a caliber of 27 to 30 F. The narrowest portion is the meatus, which is 21 to 28 F. The floor of the urethra has numerous lacunæ representing the openings of the glands of Littré.

The Penis

Contusions and Wounds.—*Contusions* of the penis require no especial treatment. Usually hot applications relieve discomfort. Extravasation of blood or serum may be checked by gentle pressure and elevation of the pelvis. Large blood clots should be cut down upon and removed. Edema of the prepuce is best cured by circumcision or multiple punctures. Gentle pressure by a roll of gauze, wet with alcohol and water, is effective.

Wounds of the penis are important because of the danger of gangrene and sloughing if infection occurs. The utmost care must be taken to prevent this accident. Bleeding should be checked, the wound cleansed, and the edges carefully united by sutures. Bromide or other sedative should be given to prevent erections.

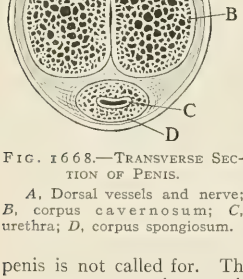


Fig. 1668.—Transverse Section of Penis.

A, Dorsal vessels and nerve; *B*, corpus cavernosum; *C*, urethra; *D*, corpus spongiosum.

If the *urethra* has been injured or if the wound is close to the urethra a catheter should be left in the bladder as swelling is quite apt to close the urethra. If a wound of the urethra is large enough to be seen, or is known to be more than a small puncture, a perineal urethrotomy should be done. Larger wounds of the urethra should be sutured. The great danger is urinary infiltration of the tissues outside of the urethra, and perineal urethrotomy is the best precaution to prevent it.

As soon as gangrene appears the wound should be opened and drainage secured. *Sloughing* should be treated by cutting away only the dead tissue. Amputation of the penis is not called for. The great vascularity of the organ may be relied upon to preserve it even in the presence of much sloughing. After the wound has granulated and healed, plastic operation will do much toward overcoming deformity.

The hemorrhage arising from *rupture of the frenum* is usually best controlled by tying the bleeding vessel.

Fracture of the penis (laceration of the corpora cavernosa or corpus spongiosum when the penis is in the erect state) should be treated the same as contusions and wounds. The organ should be cleansed, the pubic hair shaved, and a moist antiseptic dressing applied. Extravasation of blood, if extensive, requires incision, evacuation of the clot, and suture of the wound. Anaphrodisiacs should be administered. The patient should lie in bed. The pelvis should be elevated. If operation is done, there is a better prospect of the penis not becoming deformed, and the prospects of potency are better.

Dislocation of the penis, causing the organ when in a flaccid state to be forced beneath the neighboring fascia, is to be treated by causing it to retrace the course it took when dislocation occurred. If rupture or angulation of the urethra cause extravasation or obstruction, perineal urethrotomy should be done.

Strangulation of the penis, caused by a foreign body, such as a ligature, rubber band, or a ring, should be treated by removal of the strangulating body. Metallic rings may be cut or filed in two. If the circulation of the organ has been shut off and gangrene has developed, removal of the gangrenous parts only is indicated. Perineal urethrotomy should be done if extravasation of urine is present. Strangulation, caused by a circular scar, should be treated by longitudinal division of the constricting band in two or more places (see Gangrene of the Penis, page 252).

Inflammations of the Penis.—*Simple inflammation* of the subcutaneous tissues is to be treated by rest in bed, immersing the organ every hour or oftener in a hot solution of mild antiseptic such as boric acid, and the allaying of sexual excitement. Intractable phimosis or paraphimosis require operative treatment.

Balanitis is prevented by preventing urethritis, by cleanliness, and by removing the elongated foreskin. During the infective stage operation is not desirable if the inflammation can be cured by other measures. The insertion of the small nozzle of an irrigator under the prepuce and washing it out at least once a day with mild antiseptic solution will cure most cases of *preputial balanitis*. Collections of smegma should be swabbed out. If the opening is large enough, a mild dusting powder, such as stearate of zinc and subgallate of bismuth, may be swabbed about under the prepuce after it has been dried out. If the infection is due to urethral discharge cleansing irrigations should be used frequently and as soon as the balanitis has been controlled, circumcision or longitudinal incision of the prepuce should be performed.

Preputial balanitis in cases in which the prepuce can be easily retracted, is treated by cleansing and the application of a dry dusting powder (zinc stearate and bismuth subgallate).

In *gangrenous balanitis*, there is a special infective agent, an organism or organisms which are the same or similar to those found in noma and hospital gangrene. The disease, therefore, requires exposure to oxygen. The prepuce should be incised in the mid-dorsal line and the glans freely exposed. The parts should be cleansed with hydrogen peroxid solution. Free exposure to the air is essential.

Chancroid (non-syphilitic venereal ulcer) is a disease of the dirty and debilitated, and should be treated by cleansing the patient, rest in bed, good food, and fresh air. This constitutional care will prevent bubo and spread of the disease. Every sore should be examined for spirochetes to eliminate syphilis. Any sore can be anesthetized for treatment by applying 10 or 20 per cent. cocain solution to the cleansed surface.

Abortive treatment may be aimed to convert the infected sore into a sterile one. This may be accomplished by the actual cautery heated to a cherry red. Chemical cauterization may be done with crystals of pure argyrol, or with phenol followed by nitric acid. Abortive treatment should not be applied unless it can be done thoroughly and can be accompanied by rest and good hygiene. Abortive treatment should not be applied until syphilis is positively ruled out of diagnosis. It should not be used if the ulceration is very extensive. If inguinal adenitis is present the treatment cannot be abortive because the infection has usually extended beyond the sore, and the adenitis is aggravated by irritating the ulcer. The radical measures are also contraindicated if the sore is congested and edematous.

The sore should be kept free from pus. Several times daily the sore should be washed with antiseptic solution if pus accumulates. A wet antiseptic dressing is best, but if this can not be used a dry antiseptic powder may be

applied. Incision of the prepuce should be done only when absolutely necessary, as the wound is apt to become infected and converted into chancroid.

If the sore is sluggish, granulations may be stimulated by silver nitrate or balsam-of-Peru. Exuberant granulations should be removed. The glans should be kept scrupulously clean.

Pronounced and well-developed chancroid is cured by local anesthetization, application of 25 per cent. copper sulphate, and introduction of violet ray directly into the sore by means of the glass vacuum tube for five minutes. One treatment usually suffices. Healing chancroid requires only the mildest treatment.

Treatment by *fulguration* is capable of curing most cases. F. W. Robbins and F. P. Seabury (Jour. Am. Med. Assoc., Oct. 13, 1917) applied to the anesthetized and cleansed sore a 25 per cent. solution of copper sulphate and then treated it with the short high-frequency electric spark from a fine-pointed vacuum electrode. The treatment is applied from one to three minutes. Every crack and crevice is treated. This treatment may have to be repeated in four days.

Chancroid, when small and mild, is cured by cauterizing with silver nitrate and applying a good amount of calomel. Most small sores heal, without the use of silver nitrate, under the application of calomel alone. Bismuth subiodid or bismuth subgallate, mixed with calomel or zinc stearate, is effective. Thymol iodid is useful. Orthoform powder or chloral hydrate (2 per cent. solution) are used when there is pain. Medication is kept in place with a gauze dressing.

Of all of these agents silver nitrate or argyrol is the most satisfactory application.

Chancre (syphilitic) should be kept clean, and not be permitted to touch another person. Treatment should not be applied until a positive diagnosis has been made by the discovery of the pale spirochetes. Then it may be protected from irritation, and covered with an antiseptic powder (calomel and bismuth) while the constitutional treatment of the disease proceeds (see Syphilis, Vol. I, page 283).

Gangrene of the penis should be treated by removal of the cause. Constriction or pressure should be relieved. A metallic ring acting as a constricting agent may be removed by passing beneath it a grooved director. Upon this a needle carrying a double silk thread is passed. The thread is used to draw through a Gigli wire saw, with which the ring is sawed through in one or two places. If phimosis is present circumcision should be done. Paraphimosis should be relieved. If accompanied by extravasation of urine perineal urethrotomy should be performed. Moist gangrene or gangrene with raw surfaces calls for a wet dressing of antiseptic solution such as bichlorid of mercury (1:5000). The patient should be kept in bed. Gangrenous tissue should be cut away as soon as the skin becomes broken. In *dry gangrene* the penis should be kept dry and clean. An enveloping powder of boric acid is desirable. When a line of demarcation has appeared amputation should be done. In performing the amputation only the gangrenous tissue should be removed; it is not necessary to amputate above the line of demarcation. It will often be found that the gangrene of the skin extends higher than that of the erectile bodies and the amputation of the latter can be done lower than that of the skin. In many cases only the prepuce requires to be removed.

Tumors of the Penis.—The benign tumors (such as lipoma, angioma, chondroma, adenoma, osteoma, horny growths and cysts) require the same treatment as in other parts.

Papillomata (warts) are the common benign tumors, and should be treated first by cleanliness. The tumors should not be permitted to be irritated or to come into contact with other parts. Small recent warts are cured by touching the tip of each wart once daily with lactic acid. In the case of older and larger warts, a cure may be secured by the application twice weekly of nitric acid or acid nitrate of mercury. These cauterants cause pain. The best treatment for all cases excepting those amenable to treatment with lactic acid is excision with the knife. Large masses should be excised as a tumor. Circumcision is often required at the same time. Where there are multiple deposits, a rubber band to prevent bleeding should be placed about the penis, each wart should be picked up with forceps, and snipped off with scissors along with a bit of healthy skin at its base. The wound should then be touched with the cherry red cautery. All of the wounds should then be dressed with antiseptic powder, the bandage being applied in such a way as not to cover the meatus.

Carcinoma should be treated by early radical operation. If the growth involves the glans alone, amputation at about the middle of the penis is to be done. Carcinoma of the body of the penis demands complete removal of the organ. An exception to the above rules is epithelioma of the skin; this growth requires less radical operation, excision of the growth with the adjacent tissue being sufficient. In all cases enlarged inguinal glands should be removed (see Operations on the Penis, page 255).

Sarcoma requires early and complete extirpation of the whole organ (see Operations, page 255).

Anomalies and Other Pathologic Conditions.—*Phimosis* should be treated by operation, which should consist in longitudinal dorsal incision of the prepuce or circumcision. The reason for operation is that secretions and infective material are retained between the prepuce and glans unless the glans can be exposed easily for cleansing. A long prepuce does not constitute phimosis, and in a cleanly person such a prepuce does not require to be removed. Operation is required in cases in which retraction of the prepuce so as to expose the glans is impossible or difficult on account of the small size of the preputial orifice, and in cases of long prepuce as a preventive or as a cure of infection (see Operations, page 257).

Adherent prepuce is a common complication of phimosis. It occurs also in cases in which the preputial opening is large. It is met in most cases requiring circumcision. Such adhesion of the prepuce to the glans should be prevented by retracting the infant's prepuce to expose the glans and corona *completely* when the child is a few days old. This should be one of the duties of the physician accoucheur. When the child is bathed, or at least once or twice a week, the foreskin should be retracted and the sulcus behind the corona cleansed. Often this retraction is carried only to the corona; the neck is the important part to be cleansed. If the adhesions can not be separated by simple pressure with the fingers, a probe should be used. If bleeding occurs, the adhesions will form again unless the surfaces are kept apart. Nothing is better to accomplish this than a copious application of powder which should frequently be renewed.

Paraphimosis should not be allowed to remain as ulceration and gangrene are apt to follow. If the condition is accompanied with inflammation and infection, these should be treated. *Reduction* of the paraphimosis should be attempted at once. The edematous fluid of the glans and prepuce should be squeezed out of the tissues by compression. This may be accomplished by a smoothly applied elastic bandage or by circular compression in the hand, and compression of the glans by the fingers of the other hand. After a few

minutes of compression the swelling of the glans and foreskin may be diminished sufficiently so that the penis may be grasped in the fist, and the glans pushed back through the constricting prepuce by means of the tips of the fingers of the other hand.

By injecting a small amount of adrenalin with an anesthetic solution into the edematous tissues lying on the glans the swelling is reduced, and retraction of the foreskin often made possible.

When reduction cannot be accomplished the constricting band should be divided by a longitudinal dorsal incision. This is what nature often does by ulceration. In old cases the prepuce becomes infiltrated with connective tissue and can never be restored to a natural condition. It is usually desirable to complete the operation by performing circumcision.

Hypertrophy (megalopenis), when due to inflammation, is amenable to treatment. Congenital enlargement of the penis has not been treated successfully. It is possible that, in cases in which the hypertrophy is so great as to prevent coitus, a functionating organ may be secured by the excision of a longitudinal wedge from each corpus cavernosum and from the glans.

Rudimentary penis (micropenis), usually being associated with a general progression toward femininism, is not amenable to surgical treatment.

Priapism is a symptom of some other condition which is often amenable to treatment. When due to chronic irritation such as stone in the bladder, adherent prepuce or pin worms, removal of the cause cures the disease. When due to rupture of cavernous tissue and extravasation of blood, incision and removal of the clot is necessary. Priapism of central nervous origin subsides with the cause. Nerve sedatives such as bromids, morphin, hyoscyamus, atropin and chloral are sometimes of service. Syphilis should always be borne in mind, as intractable cases have been due to central irritation and yielded to appropriate antisyphilitic treatment. Ligation of the dorsal arteries of the penis has given relief. Injection of the pudic nerves should cause relaxation of the erector muscles. Incision and drainage of the corpora cavernosa have relieved most cases upon which they have been done.

The operation of incision of the corpora is indicated in cases of mechanical origin. Incision is made near the base of the penis on the dorsolateral aspects. This incision must pass down through the capsular fascia of the penis well into the spongy tissue of the organ. One incision may suffice, as the two sides anastomose, but since clots are often present, an incision on either side is the most certain cure. The blood is apt to be thick and clotted, and must be squeezed out. For this reason the incisions must penetrate well. A wick drain should be introduced after the blood has been evacuated. Rigid asepsis is essential, as infection means fistula or possible sloughing of the urethra.

Curvature of the penis may be cured by plastic operation. These operations consist in converting a V-shaped incision into a Y or a T, and in securing elongation of tissue in the desired direction by approximating the two ends of a straight incision one to another and converting the middle of the incision into ends of the closed wound. The incisions for these purposes should pass into the contracted tissues. If the contractures involve the erectile bodies the incisions should pass into their substance. More than one of these incisions may be required (see Plastic Operations, page ooo).

Short frenum, giving rise to downward curvature of the glans, is cured by V-shaped division of the frenum in one or more places and closure of the wound as a Y or T. Transverse division of the frenum and closure of the wound longitudinally is also effective.

Sclerosis of the erectile bodies is not amenable to surgical treatment.

Adherent penis (webbed penis), attachment to the scrotum throughout the whole or part of its length, is treated by plastic operation, which must often be combined with operation for hypospadias.

Herpes is to be treated by the rules already given (see Vol. I, page 829).

Hypospadias and *epispadias* are to be treated by operation (see pages 261 and 270).

Operations on the Penis.—*Ligation of the dorsal vessels* may be done for injury or disease. The vessels lie beneath the deep fascia in the groove between the two lateral corpora. A median incision about 2 cm. (¾ inch) long is made just in front of the pubes. The superficial dorsal vein lies just under the skin. The larger vessels are reached after longitudinal incision of the fascia covering the corpora. The fascia may be divided on a grooved director. It should be remembered that there is a median single dorsal vein and two dorsal arteries. The vein lies between the two arteries. There are two nerves, one on the outer side of each artery. The superficial dorsal vein should not be mistaken for the more important deeper vein.

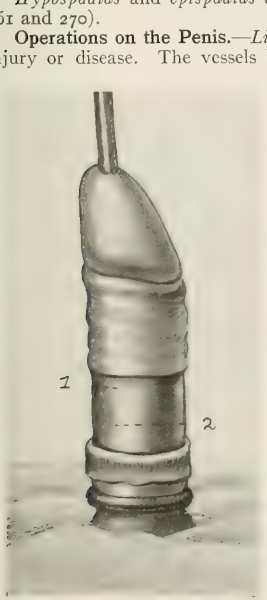


FIG. 1669.—AMPUTATION OF PENIS.
1, Level of division of skin and urethra; 2, level of division of corpora cavernosa.

FIG. 1670.—AMPUTATION OF PENIS.
Completed operation. The urethra and skin are sewed together.

Amputation of the penis is usually done for carcinoma. A sound or catheter is inserted into the urethra and an elastic ligature is placed about the organ at its root. If there is a tendency to phimosis, the prepuce should be divided freely to expose the glans. The glans is grasped with tenaculum forceps, drawn forward, and held by an assistant. The assistant also holds the sound. A circular incision is then made through the skin well back of the disease. The skin flap is dissected back far enough to provide a flap to cover the stump. The corpora cavernosa are then divided. The urethra with its surrounding spongy tissue is then dissected free and divided at a distance of about 1 cm. (⅓ inch) anterior to the point of division of the cavernous bodies (Fig. 1669).

The dorsal artery and veins are then tied. The constricting ligature is removed. Some blood rushes out of the erectile sinuses and bleeding then usually stops. The divided surface of erectile tissue is covered in by a few sutures of fine catgut passing from side to side. The urethra is then divided on its floor for about 7 mm. (¼ inch). The skin is then pulled over the stump. A suture catches the urethra on either side and fastens it to the skin at the lower angle of the wound. The rest of the skin is then approximated in a vertical line (Fig. 1670). The object of longitudinal division of the mouth of the urethra is to insure against cicatricial narrowing. A catheter should be inserted into the bladder for continuous drainage for two days.

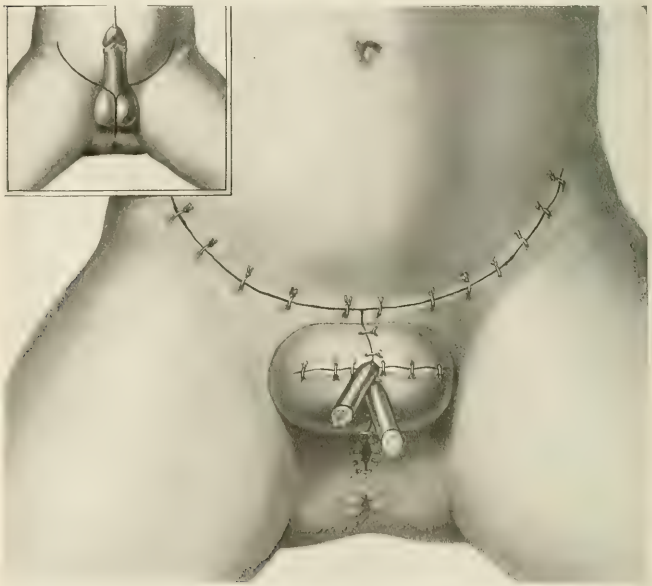


FIG. 1671.—RESULT AFTER EXTIRPATION OF PENIS AND LYMPHATICS.
The urethra is sewed to the skin in the perineum, cigaret drains are inserted, and the wounds closed by interrupted sutures.

Extirpation of the penis, when done for carcinoma, should included removal of the glands of the groins. An incision should begin at the outer part of Poupart's ligament on one side, follow the ligament to the pubic bone, pass horizontally across above the root of the penis, and pass in front of Poupart's ligament to a corresponding point on the opposite side. One side should be done at a time. The skin flaps should be dissected up on either side of the wound. The fat and glands lying in front of Poupart's ligament and in Scarpa's triangle are dissected free. The same is done in the opposite groin. The dorsal vessels of the penis are then ligated through the transverse wound at its root.

A sound is then introduced into the urethra. An incision is carried around the root of the penis and thence down the middle line of the scrotum, following the raphé of the scrotum, to the perineum. By blunt dissection and with the aid of the scissors the scrotum is split in two, the cleavage being between the two tunicæ vaginales, each enveloping a testicle. The two halves of the scrotum are held apart and the corpus spongiosum is exposed in the wound. The corpus spongiosum is then dissected away from its connection with the corpora cavernosa. The bulbous urethra is then freed from the corpora cavernosa, and the arteries of the corpora tied and divided before they enter the bodies. Lying close to these are the dorsal vessels of the penis. After tying all of these vessels, the dissection is continued from behind forward. The sound is removed and the spongy body enveloping the urethra is divided across as far forward as is compatible with safety from disease. The urethra thus freed may be isolated as far back as the triangular ligament.

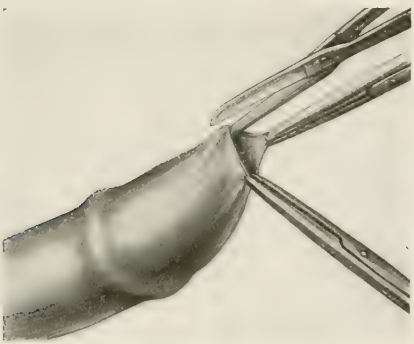


FIG. 1672.—DORSAL INCISION FOR TIGHT PREPUCE.

The skin is dissected up at the base of the penis, the suspensory ligament divided and the cavernous bodies freed from their pubic attachments. The penis is thus removed, together with the lymphatic tissues of the groins, which remain attached to it. Bleeding vessels are tied. The urethra is cut longitudinally on its lower surface for about 1 cm. (⅓ inch) and its mouth, thus enlarged is sutured to the skin of the perineum, posterior to the scrotum. The rest of the wound is closed, and a catheter for urinary drainage is left in the urethra. This should be left for about five days to insure against urinary irritation of the wound and infiltration (Fig. 1671).

Dorsal incision of the prepuce is done for phimosis. It accomplishes all that circumcision does, excepting elimination of the foreskin. A grooved director is passed between the glans and prepuce, and upon this as a guide a long, narrow-bladed knife is passed up to the top of the subpreputial space and caused to divide the prepuce in the middle line throughout its entire length. Some surgeons prefer to use sharp-pointed scissors. If the preputial opening is very small it may be grasped by two clamps to hold it forward (Fig. 1672). It has happened that the director has been accidentally passed into the urethra and the latter laid open in this operation. To

avoid this accident the incision may be made from the skin toward the glans. The angular corners of prepuce at the lower end of the wound should be rounded off and the wound dressed as for circumcision. In babies of a few days of age no anesthetic is necessary.

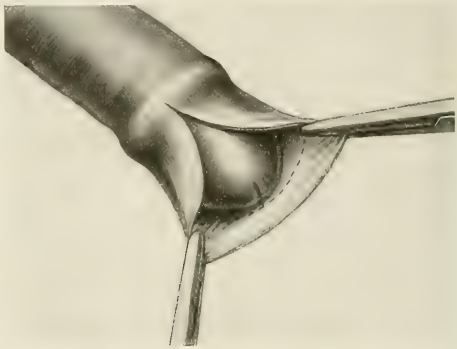


FIG. 1673.—CIRCUMCISION.
The foreskin is held by clamps. The dorsal median incision has been made. Scissors cut off the foreskin along the dotted line.

Circumcision is for the removal of a part or the whole of the prepuce. In many cases which are brought to the surgeon for circumcision it will be found that the foreskin has been permitted to become adherent to the glans penis and that when these adhesions are separated the preputial opening is

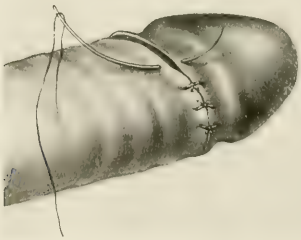


FIG. 1674.—CIRCUMCISION.
Showing incisions completed. Suture in process of application.

wide enough to permit easy retraction of the foreskin and no further operation is necessary. When a cutting operation is required dorsal incision in many cases will be found sufficient.

Circumcision in children is done as follows: After careful cleansing

of the parts, the operation of dorsal incision of the prepuce is practised. The prepuce should be cut through both skin and mucous layers as far back as the sulcus at the neck of the penis. All adhesions between the prepuce and glans should be broken down by pressure with the thumbs. The operation is facilitated by the application of a small clamp to each

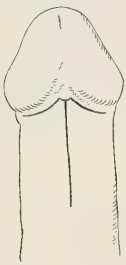


Fig. 1675.

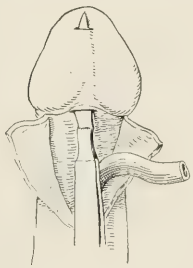


Fig. 1676.

Fig. 1675.—Operation for Hypospadias.
Incisions.

Fig. 1676.—Operation for Hypospadias.
The urethra is dissected free and the glans penis is punctured with a narrow knife to make a canal for it.

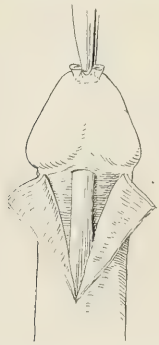


Fig. 1677.

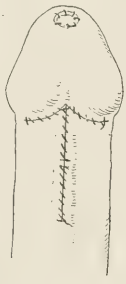


Fig. 1678.

Fig. 1677.—Operation for Hypospadias.
The urethra is drawn through the new canal in the glans penis.

Fig. 1678.—Operation for Hypospadias Completed.

edge of the wound. The foreskin is now cut off with scissors—evenly and on a level with the corona glandis as the skin lies naturally without tension (Fig. 1673). The mucous layer of the prepuce should be divided at the same level as the skin. The corners at the junction of the dorsal and circular incisions should be cut off. It is important that the dorsal incision should

extend above the corona so that as the incisions are completed the preputial opening shall be larger than though a circular incision alone had been made. A small vessel at the frenum requires to be ligated. Occasionally other vessels have to be caught.

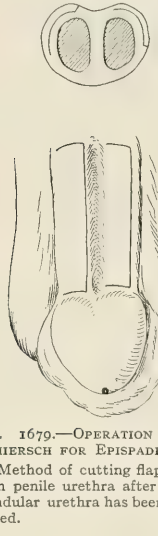


FIG. 1679.—OPERATION OF THIERSCH FOR EPISPADIAS.

Method of cutting flaps to form penile urethra after the glandular urethra has been restored.

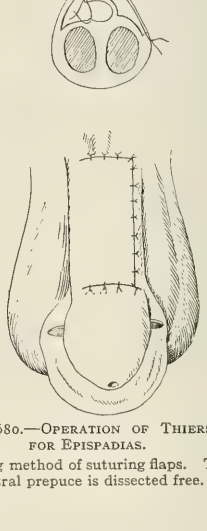


FIG. 1680.—OPERATION OF THIERSCH FOR EPISPADIAS.

Showing method of suturing flaps. The ventral prepuce is dissected free.

The wound is closed with fine interrupted catgut sutures approximating the skin and mucous membrane of the prepuce (Fig. 1674). The wound is dressed by wrapping about the penis a strip of gauze smeared with zinc oxid

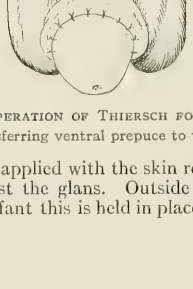


FIG. 1681.—OPERATION OF THIERSCH FOR EPISPADIAS.

Showing method of transferring ventral prepuce to the dorsum of the penis.

ointment. This should be applied with the skin retracted so that the wound edge is not infolded against the glans. Outside of this should be applied a ring of gauze. In the infant this is held in placed by the diaper. In older

children and adults a couple of strips of adhesive plaster or a diaper bandage is used.

The operation requires a general anesthetic in children. Local anesthesia may be used in adults. The patient should be kept quietly in bed to promote healing. The wound should be dressed daily or as often as it becomes soiled with urine. Particular attention should be given to the prevention of adhesion. At each dressing the prepuce should be pressed away from the glans and the sulcus filled with ointment or powder.

This operation, which among some is performed as a religious rite, may properly be adopted as a general sanitary measure to be applied to all male children. The operation promotes cleanliness; it prevents phimosis and

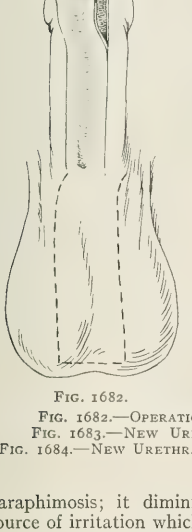


FIG. 1682.

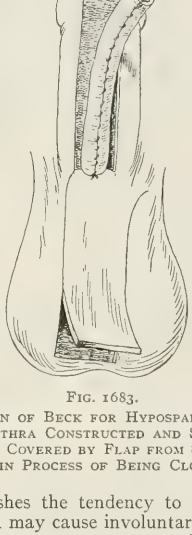


FIG. 1683.

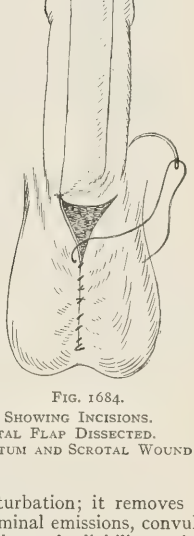


FIG. 1684.

FIG. 1682.—OPERATION OF BECK FOR HYPOSPADIAS, SHOWING INCISIONS.
FIG. 1683.—NEW URETHRA CONSTRUCTED AND SCROTAL FLAP DISSECTED.
FIG. 1684.—NEW URETHRA COVERED BY FLAP FROM SCROTUM AND SCROTAL WOUND IN PROCESS OF BEING CLOSED.

paraphimosis; it diminishes the tendency to masturbation; it removes a source of irritation which may cause involuntary seminal emissions, convulsions, enuresis and other nervous symptoms; it reduces the liability to infection with syphilis and chancroid; it diminishes the liability to venereal warts and epithelioma; and it prevents balanitis and its allied infections.

Hypospadias is best treated after the child is one or two years old, although the operation may be done, by skillful hands, upon younger infants. The operation commonly performed consists in dissecting free the corpus spongiosum from the corpora cavernosa, making a punctured tunnel through the distal part of the penis, emerging at the apex of the glans, and pulling through this tunnel the liberated urethra. A rubber ligature is placed at the base of the penis. An incision is made around the orifice of the urethra, leaving a cuff of tissue around the opening. A longitudinal incision is carried from this in the median line along the under surface of the penis. This divides skin

and superficial fascia and exposes the bluish glistening surface of the corpus spongiosum. A transverse incision passes from the lower end of this incision

Fig. 1685. Fig. 1686. Fig. 1687.

Fig. 1685.—Operation of Szymanowski for Hypospadias.
This stage of the operation should be preceded by the construction of a urethral passage through the glans.

Fig. 1686.—Construction of Flap for Covering Urethral Defect.
Fig. 1687.—Closure of Wound after Covering Urethral Defect.

to either side, embracing about one-third of the circumference of the penis (Fig. 1675). A small catheter is passed into the urethra, and the skin and

Fig. 1688. Fig. 1689.

Fig. 1688.—Securing an Epithelial Lining for the Distal End of the Reconstructed Urethra through the Glans.
Fig. 1689.—Loop of Skin Drawn through Glans.

superficial fascia are dissected back on either side as far as the septum between the spongiosum and the cavernosa. The urethra, surrounded by its

FIG. 1690.—OPERATION OF BECK FOR HYPOSPADIAS (FIRST STAGE).
Incisions for first stage of operation. This operation is indicated in the pronounced cases with a scrotal or scrotopenile meatus.

FIG. 1691.—OPERATION OF BECK FOR HYPOSPADIAS (SECOND STAGE).
The dorsal bridge flap has been swung downward and sewed in the wound below the glans.

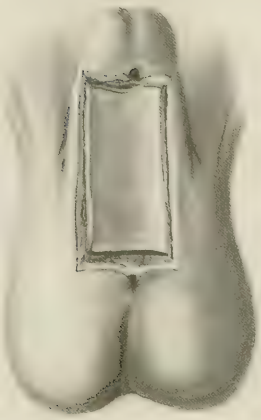


FIG. 1692.—OPERATION OF BECK FOR HYPOSPADIAS (THIRD STAGE).
The skin for the formation of a new urethra is marked out after the first wounds have healed.

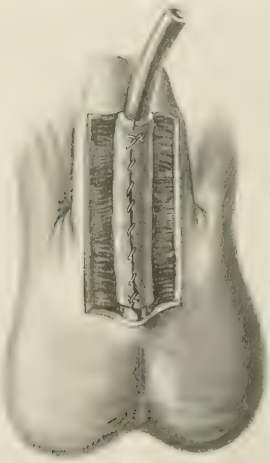


FIG. 1693.—OPERATION OF BECK FOR HYPOSPADIAS (FOURTH STAGE).
The new urethra is constructed by uniting the skin over a catheter.

spongy body, is then dissected free from the corpora cavernosa as far back as is necessary to liberate a length sufficient to reach to the apex of the glans. With a narrow straight knife or trocar, a puncture is made from the lower ends of the bed of the dislocated urethra through the substance of the organ to emerge at the apex of the glans slightly toward its dorsal aspect (Fig. 1676). This may be enlarged if necessary by dilating with forceps. Fine forceps are passed through this canal and caused to grasp the end of the free urethra which is pulled through the canal (Fig. 1677), and its mouth united to the new meatus by four or five fine silk sutures. The skin wound is then closed and a permanent catheter is left in the urethra for bladder drainage for a few days (Fig. 1678).

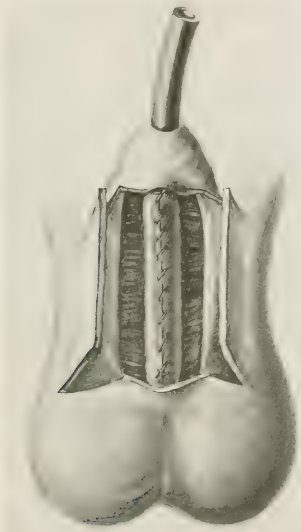


FIG. 1694.—OPERATION OF BECK FOR HYPOSPADIAS (FIFTH STAGE).
Plastic for covering denuded surface.

The above operation is applicable to the cases in which the urethral orifice is not far above the glans. In the cases in which the opening is farther up as in the penile, scrotal, or perineal form, a series of plastic operations must usually be done. In these cases operation had better be deferred until the child is four years old or older. The first operations should be done to straighten the penis and liberate it from adhesions and contractions on its under surface.

For the restoration of a missing part of the urethra, after straightening the organ, and reconstruction of the glandular urethra, the method devised by Thiersch is to be recommended (Fig. 1679). Before beginning the plastic operation a perineal urethrotomy is done to divert the urine temporarily from

the field of operation. Two lateral rectangular flaps are made in such a way that one may be superimposed upon the other, the skin epithelial surface of one being used for the lining of the new canal (Fig. 1680). A dorsal prepuce is made by incising the ventral prepuce transversely, carrying it over the glans, and sewing it on the dorsum (Fig. 1681).

Another operation reconstructs a new urethra by folding together the skin from either side of the groove where the urethra should be (Figs. 1682 and 1683), and then covers the wound by a flap from the scrotum (Fig. 1684). The tip of the new urethra may be drawn through the glans as in the first operation described; or a urethra may be made of the vermiform appendix.

Fig. 1695.—Operation of Beck for Hypospadias (Sixth Stage).
Result after last operation.

After healing has been secured a catheter is passed, and the perineal fistula is allowed to heal. With care and patience these operations may be carried on to success; commonly they fail for lack of these essentials.

The operation performed by Szymanowski is applicable to defects of the floor of the urethra which have the nature of a fistulous opening. An incision, beginning above and ending below the opening, is carried through the skin close to the margin of the opening (Fig. 1685). The skin is undermined from the opening outward. This subcutaneous dissection should be carried far enough to receive a flap from the other side of the opening. This flap is made by carrying a curved incision along the other side and dissecting up the

skin as far as the fistulous opening. The skin flap is then carried under the undermined skin and fixed by interrupted sutures which should not involve too much of the base of nourishment of the undermined skin (Fig. 1686). The edge of the undermined skin is then sewed to the edge from which the flap was taken, thus leaving skin epithelium turned in to line the defective tract and the wound finally covered by a second flap of skin (Fig. 1687).

The operation of H. Russell consists in cutting free a loop of skin (Fig. 1688) and drawing it through the punctured glans to form the distal end of

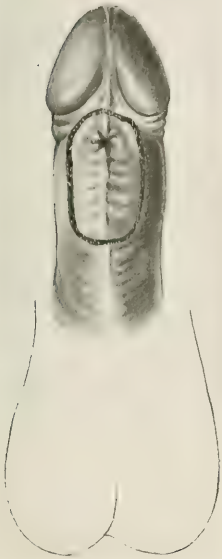


FIG. 1696.—OPERATION FOR HYPOSPADIAS DEVISED BY BEVAN.
An incision is made about the abnormal meatus.

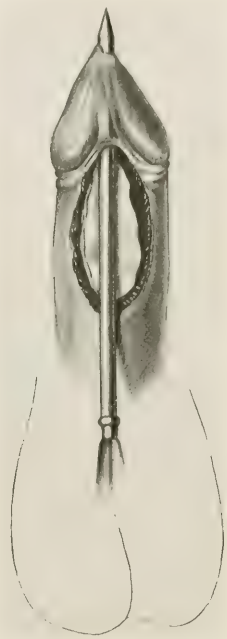


FIG. 1697.—MAKING A NEW CANAL THROUGH THE GLANS PENIS IN THE OPERATION OF BEVAN.

the urethra (Fig. 1689). The rest of the urethra is reconstructed by a skin plastic as described above.

Cantas dissected up a segment of the internal saphenous vein, implanted it under the skin of the penis, and cut it free after it had become attached in its new bed. This serves admirably for the new urethra.

A most effective operation is that devised by C. Beck (Surg., Gyn., and Obst., May, 1917). He made an incision transversely between the meatus

and the glans. This wound is spread open vertically 4 or 5 cm. (1½ or 2 inches). A flap in the form of a bridge is then cut from the skin above the glans (Fig. 1690). This bridge is swung downward over the glans and sewed in the wound below the glans (Fig. 1691). After three or four weeks an

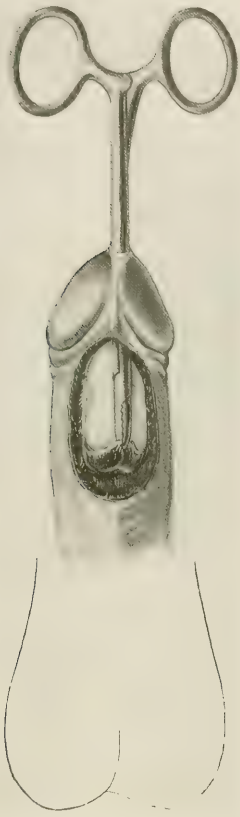


Fig. 1698.—Drawing the Skin through the New Canal in the Operation of Bevan.

oblong of skin is marked out between the meatus *de facto* and the place where the meatus should be. This skin area should be big enough to form a urethra (Fig. 1692). This is sewed about a catheter in such a manner as to form a tube. For this purpose Beck advises horsehair interrupted sutures, tied inside the tube and cut very short (Fig. 1693).

In the course of time these sutures come away spontaneously. The raw surface remaining may be covered by swinging in a flap of skin from either side, puncturing the glans to continue the new urethra through it, and connecting the upper end of the new urethra with the meatus (Fig. 1694). This latter step is the same as closing a urethral sinus. By carrying an incision backward from the elevated wound on either side a flap may be dissected up and the two flaps sewed together in the median line on the bottom of the penis (Fig. 1695).

FIG. 1699.—SEWING THE SKIN, FORMING THE CONTINUATION OF THE URETHRA, TO THE NEW MEATUS IN THE OPERATION OF BEVAN.

For cases with the opening of the urethra just above the glans penis the operation devised by A. D. Bevan (Jour. Am. Med. Assoc., Apr. 7, 1917) is to be recommended. An incision through the skin is made marking out an oblong area, extending as far down as the glans and having the abnormal meatus at its lower end (Fig. 1696).

A canal is then made with a trocar through the glans from the lower end of this skin wound to the apex of the glans (Fig. 1697). Two very fine artery

forceps are then passed upward through the new opening and caused to grasp the two extreme ends of the skin flap (Fig. 1698). This is cut free and drawn through the new canal. Its border composed of the two ends of the skin flap is sewed to the new meatus (Fig. 1699). The skin wound left by the operation is closed by sewing the skin over it laterally or by means of a plastic skin flap.

Epispadias varies so much in its degree that operation for its relief must be adapted to the nature of the case. In complete epispadias with rudimentary penis operation has nothing to offer except the cosmetic reconstruction of a structure in lieu of a penis. Epispadias in which there is a

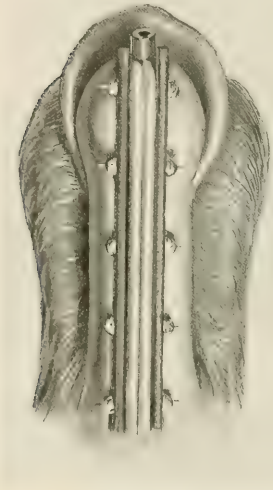


Fig. 1700.

Fig. 1701.

Fig. 1700.—Operation for Epispadias

Showing incision through skin and superficial layer of deep fascia.

Fig. 1701.—Operation for Epispadias.

The skin is sewed over the urethral groove, to form an epithelial lining for the new urethra. The skin external to the new urethra is held over it by sutures through silver strips.

fair amount of cavernous tissue is worthy of operative treatment. If there is a urethra opening at the base of the organ and a groove on the dorsum, the crests on either side of the groove may be freshened and brought together over the groove to form a canal (Fig. 1700). To increase the caliber of the urethra, a longitudinal incision should be made at the bottom of the groove. The surface freshened on either side should be about 0.75 cm. (¼ inch) wide, and about 1.3 cm. (½ inch) from the middle line. A catheter is laid in the groove and the denuded surfaces are brought together over it and held by silver wire sutures caught at the ends with lead buttons. A pad of

zinc oxid gauze should be placed under each button (Fig. 1701). The sutures and catheter should be left in for about seven days. After removal of the sutures urine may be allowed to pass through the new urethra.

Cases in which the groove is not deep enough or in which there is not sufficient tissue a dorsal urethra may be constructed by one of the operations devised by Beck for hypospadias.

The Urethra and Accessory Organs

Injuries of the Urethra.—*Contusions* require that the urine should be rendered as little irritating as possible and that sexual excitement should be kept in abeyance.

Wounds of the urethra are serious because of the danger of infiltration of urine and infection. To prevent this a catheter should be left in the urethra to drain the bladder or perineal section done. A urinary antiseptic should be given, and the patient should be kept quiet. These things apply to all cases. Hemorrhage should be checked by some of the measures already laid down. If necessary the bleeding wound should be exposed and torn vessels ligated. Retention of urine may have to be dealt with. When there is an external wound it should be dressed. If it is large it should be sutured, and to prevent irritation a catheter should be left in the urethra to drain the bladder. Gunshot wounds require that urine shall not pass in contact with the wound until healing has been secured. Sexual excitement should be allayed. The urine should be rendered as little irritating as possible.

Extensive lacerated wounds should be sutured and the urine diverted by perineal drainage. Rupture of the urethra without extravasation of urine may be treated by leaving in the bladder a permanent urethral catheter. If a catheter cannot be passed perineal drainage should be established. Complete division of the urethra should be treated by exposing the seat of rupture, sewing the two ends together with fine interrupted chromic catgut sutures, and leaving a urethral catheter for bladder drainage. Suprapubic cystotomy may be necessary in some cases of rupture of the deep urethra in order to locate the opening of the proximal segment by means of retrograde catheterization.

Extravasation of urine, as a complication of wounds or rupture of the urethra, should be prevented by keeping urine from passing over wounds of the urethra by means of the catheter à demeure, cystotomy or perineal urethrotomy. Infiltration due to ulceration above a stricture should be prevented by the prevention and early relief of strictures. The urethra in these inflammatory cases should be restored to its normal caliber as soon as possible. In all cases as soon as extravasation of urine is observed perineal section should be done if the leakage is posterior to the penile urethra.

In rupture of the deep urethra, with infiltration of the tissues of the perineum with blood and urine it may be difficult to find the torn ends of the urethra. A perineal section having been done and the edges of the wound well retracted, the distal end may be found by passing a bougie through the penile urethra until it emerges at the wound; and the proximal opening may be found by performing suprapubic cystotomy and passing a bougie from the bladder into the urethra.

These cases are extremely serious and operation should be done at once. Rupture with extravasation in the deep urethra should be exposed by perineal section. If the rupture is complete the urethra should be sutured in the upper half of its circumference, a tube should then be inserted into the bladder through the wound and left there for about a week. At the end

of that time it may be removed and a sound passed through the whole urethra to the bladder. This should be repeated every other day until the perineal fistula has healed.

Infiltration beyond the leaflets of the triangular ligament in cases of rupture of the deep urethra, which does not clear up promptly after perineal urethral drainage has been established, should be treated by incision into the infiltrated tissues. Thus incisions may have to be made in the cellular structures of the perineum or lower abdomen.

A general septic state developing out of this condition should receive the treatment prescribed for septicemia. No constitutional treatment is of avail until free drainage of the bladder has been established and infiltrated spaces have been incised.

Simple Inflammations of the Urethra.—*Simple* (non-specific) *urethritis* is to be treated by first removing the cause. If it is due to stricture the stricture should be dilated. Stone or other foreign body causing urethritis should be removed. Highly irritating urine or glycosuria should be remedied. Infection with simple pus-producing bacteria will usually subside under the administration of a urinary antiseptic. When such a nongonorrheal discharge persists it may be cured by the injection of silver nitrate (1:10,000) every other day.

In *abscess of the urethra*, early incision is indicated when it can be reached. Usually an abscess opens spontaneously. When such an abscess extends beyond the urethra external incision is required as for abscess of the penis or perineum.

In *tuberculosis of the urethra* the treatment is the same as that for tuberculosis in other parts. Locally silver nitrate may be used.

Inflammation of the verumontanum is usually chronic and productive of characteristic symptoms. It is prevented by abstaining from the practices which produce permanent congestion of the deep urethra, such as coitus interruptus, incompleted sexual excitement, excessive coitus, and masturbation.

The simple passage of cold sounds has a most beneficial effect in these cases.

The treatment of established cases is by the application of 5 or 10 per cent. silver nitrate solution. This relieves the swelling of the mucous membrane. The complicating chronic urethritis is relieved by applying a weaker silver nitrate solution to the prostatic urethra. If the verumontanum is soft and much swollen (subacute inflammation) it may be touched directly through the endoscope with 25 per cent. silver solution or the pure caustic. The silver should be washed out with water to prevent pain. Some pure olive oil left in the urethra after the application will give comfort.

In chronic enlargement in which the veru is firm, it should be amputated. The operation is done through the urethral endoscope.

Tumors of the Urethra.—*Papilloma* may be treated through the endoscope. A pedunculated growth may be snared, cauterized, or twisted off. Sessile papilloma may be treated with caustic silver nitrate or the cautery, sounds being passed later to prevent scar contraction. *Cysts* of the urethra may be treated by puncture through the endoscope; if recurrence takes place the cyst should be exposed by external incision and its sac dissected out. *Carcinoma* of the urethra, if discovered early, may be cured by excision only of the diseased segment of urethra and the immediately adjacent tissue; but usually it will be found that the disease is extensive enough to demand amputation or extirpation of the penis.

Foreign Bodies in the Urethra.—A round foreign body, such as a stone, passing from above, usually tends to move onward but may be stopped at one of the narrow places—beginning of the membranous portion, lower limit of the bulbous portion, or at the external meatus—and there require artificial means to free it. At the meatus, it may be picked out with forceps or liberated by dividing the meatus under cocain. At the deeper sites the urethra anterior to the foreign body may be dilated by instrumental dilators or by injecting fluid. By having an assistant make pressure above the body while sterile olive oil is injected forcibly to dilate the urethra in front of it, if the patient has accumulated urine in the bladder, an effort to urinate after the dilatation may expel the foreign body. When olive oil is forcibly injected some of it passes the foreign body and thus helps the lubrication. Liquid vaselin, petrolatum, or cosmolin may be used instead of oil.

Dilatation may be secured by having the patient accumulate urine in the bladder, injecting the urethra with oil, and then causing the patient to attempt to urinate while at the same time the meatal opening is held tightly compressed so that urine cannot escape. Then, upon suddenly releasing the pressure, a burst of urine, sweeping with it the foreign body, escapes.

There are many ingenious devices in the form of forceps and scoops for removing such bodies. In the absence of these a loop of wire, bent like a coudé catheter near the end, may be passed beyond the body in the presence of oily lubrication. This may be looped over it and draw it out. A stone lodged in the deep urethra may be pushed back into the bladder and removed by litholapaxy. If it is not readily pushed back it should be removed by external urethrotomy.

Sharp and irregular bodies, such as pins, pieces of broken instrument, or other foreign substance may be removed with urethral forceps. Such removal should not be attempted if the body is firmly wedged or is of such a shape that its removal entails tearing or serious traumatization of the urethral mucous membrane. It is much safer to perform external urethrotomy. This is best done at the membranous urethra if the body can be pushed back to that position; but if not, the urethra should be incised opposite the foreign body on its lower surface, the body extracted, the wound sutured, and a permanent catheter left in the bladder for a few days or perineal drainage established.

Bodies caught in the posterior urethra or partly projecting into the bladder should be removed by perineal urethrotomy. Pins with heads and hair pins, having their sharp ends toward the meatus, can rarely be removed with forceps through the meatus. I have once succeeded in removing a pin by passing an endoscope into the urethra; the pin was then pressed upward by external manipulation at its head until the point became disengaged; the endoscope was then slipped over its point; by holding the head of the pin by external pressure the endoscope was moved up the urethra until the whole pin was in the endoscopic tube; the patient was then rolled over face downward and the pin fell out by its own weight.

An opened safety-pin in the urethra may be removed by pressing it upward and then closing and locking it by external pressure. After it is locked it may be manipulated downward through the meatus. A pin, with its point toward the meatus, may be removed by holding the head of the pin by external pressure, bending the penis at the point of the pin, and then forcing the point of the pin through the substance of the organ. As the pin emerges through the skin, the head of the pin is pressed onward until

it lies on the meatus side of the point of puncture. When the pin has been rotated thus far, the head is worked on toward the meatus, while the pin is pushed into the urethra again, moving head-first toward the meatal opening.

A needle is removed by causing it to transfix the substance of the penis. In the case of a hairpin, both points are caused to pierce the wall of the urethra and penis. It is then reversed so that the rounded end is toward the meatus and pushed out as in the manner described above for the removal of headed pins. The operation may sometimes be facilitated by cutting off one of the legs of the pin as it protrudes through the skin. The punctures caused by pins quickly heal, although to insure against infiltration of urine it is wise to empty the bladder by the catheter for the first two days after the operation. A hairpin may be removed, without wounding the urethra, by means of the endoscope and a wire snare. The snare is passed through the endoscopic tube, caused to embrace the two limbs of the hairpin, and draw them together and into the tube.

In all of these operations the utmost gentleness should be used to prevent unnecessary wounding of the urethra. The floor of the urethra is the best place for puncture or incision.

Urethral Fistula.—*Acquired fistulas* which require treatment are urethropenile, urethroscrotal, urethroperineal, urethrorectal, and combinations of these. The first step in the treatment of any of these forms is the removal of the cause. Usually there is found some obstruction, such as stricture or stone below the fistula. When due to abscess or traumatism no complication to be relieved may be present. Stricture, foreign body, ulceration or other cause having been cured, fistula usually will undergo spontaneous cure. Commonly all that is required to cure fistula is the passage of sounds to secure complete dilatation of the urethra. If there is a tight stricture gradual dilatation must be practised. If the dilatation is combined with regular catheterization to prevent urine passing through the fistula, healing is hastened.

If the fistula does not heal under the above treatment stimulation of the fistulous tract with 2 per cent. silver nitrate solution or the actual cautery may be of service. As a last resort the fistulous tract may be dissected out and the wound closed by sutures. While the healing is in progress urine should not be permitted to pass over the wound but should be diverted by suprapubic or perineal drainage, or the bladder should be drained by an inlying catheter.

In the case of large fistulous openings or defects, a cure can be secured only by urethrorrhaphy or urethroplasty. *Urethrorrhaphy* is practised for fistula by denuding the fistulous opening and closing the wound with silk sutures. If the opening is very large it should be operated upon as for hypospadias (see page 261).

Fistulas of tuberculous origin are not to be cured by operation; systemic treatment of the tuberculosis is necessary.

In *urethrorectal fistulas*, something more than dilatation of the urethra is required in many cases. A complete excision of the fistulous tract is often necessary. This should be accompanied by excision of the neighboring dense scar tissue. The opening in the rectum should be closed as for wounds of the rectum. The opening in the urethra should give access to the rest of the canal for the cure of strictures. Dense scar tissue around the deep urethra should be removed. Urethral mucous membrane should not be cut away. If there is a defect in the continuity of the urethra the operation should be concluded as that for urethrectomy.

Urethral Fever and Shock.—These conditions are produced by so great a variety of causes that measures for their prevention require a wide range of understanding of their pathology. The symptoms due to a high degree of sensitiveness of the nervous system may be prevented by getting the patient in the best possible physical condition before urethral instrumentation is practised. High blood-pressure should be reduced, fear allayed, pain prevented and elimination thoroughly established. By cocainization of the urethra, peripheral irritation may be reduced. Tolerance of the urethra to instruments may be developed gradually until the more severe manipulations may be made without harm.

Following stricture, hypertrophy of the prostate or other obstructing condition, the kidneys become accustomed to a certain increase of pressure, and when this is suddenly relieved some change takes place which upsets the functional balance and a disturbance of elimination occurs. Much of the so-called urethral shock is due to this condition and is to be prevented by the gradual relief of this pressure and by securing continuous drainage for a time prior to operation.

As infection is often an etiologic factor, the cleanliness of the urethra should be looked to before operation is done. An infected urethra should always be washed out before using an instrument which may cause openings in the mucous membrane. Such irrigation may be done by means of a small catheter passed to the deep urethra, and a continuous stream of irrigation allowed to escape around the catheter.

Urethral fever is prevented also by washing out the soiled urethra after instrumentation; by securing drainage of the urethra; and by the internal administration of urinary antiseptics for a few days before, during and after operation.

Inflammation of Cowper's Glands.—This condition, easily recognized by palpation of the affected side through the rectum, the gland being felt as a small painful mass in the perineum in acute infections and as a sensitive lump in chronic infections, is best treated by operation. Unless operation is done an abscess is apt to develop, discharge through the skin of the perineum or scrotum, and leave a urethral fistula. When an abscess has formed it should be operated upon at once through the perineum. In all operations upon these glands, the gland should be dissected out and the wound packed with gauze to heal by granulation. In cases in which cellulitis of the perineum and scrotum has developed, the infected tissue should be freely incised and the pus focus drained.

In chronic inflammation the gland should be exposed by incision and dissected out. Tuberculosis requires the same treatment as when occurring elsewhere.

Diseases of the Seminal Vesicles.—*Inflammation* of the vesicles is usually gonorrheal in origin complicated with other organisms. The milder cases heal without any treament beyond that addressed to the urethritis. In subacute and chronic inflammation of gonorrheal origin the vesicles may be emptied. To do this, the bladder is filled with fluid and the patient is caused to bend forward over a table, while the surgeon inserts the index-finger, covered by a rubber cot and well lubricated, into the rectum; gentle massage from behind forward is applied to each vesicle. The operation should not cause pain and should be continued until the vesicles seem to be empty. The massage usually requires about a minute, and is practised every other day. The contents of the vesicles may be washed out of the urethra by causing the patient to pass the fluid which has been injected into the bladder. Some cases are made worse by massage. If massage fails to empty the vesi-

cle, it should be assumed that there is stricture of the ejaculatory duct, and incision of the vesicle or of the vas should be done.

In all inflammations of the vesicles the same treatment as is applied to inflammations of the prostate and deep urethra are indicated. Autogenous vaccines may be used with good results in some cases.

If the ejaculatory duct is completely occluded massage can be of no use. If the vas is occluded near the vesicle medication through the vas cannot be expected to be of use. Medical injection of the vesicle through the vas is done as follows: The neck of the scrotum is anesthetized. A small incision exposes the vas, which is squeezed up against the skin between the fingers. A fine needle is passed obliquely through the wall of the vas into its lumen. A soft clamp, such as is used for temporary occlusion of blood-vessels, is applied distal to the puncture. From 4 to 5 c.c. (60 to 80 minims) of medical

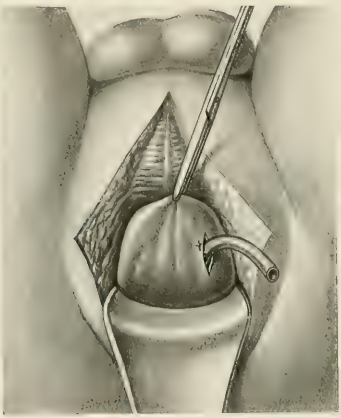


FIG. 1702.—OPERATION FOR DRAINAGE OF SEMINAL VESICLE.
Drainage tube in place.

fluid, such as silver nitrate or argyrol solution, may be injected. The little wound in the skin and fascia is closed by a suture (see Vasopuncture, below).

Vasotomy will rarely be required if massage and vasopuncture have been given a fair trial.

Abscess of the vesicles which cannot be emptied by massage, and which does not rupture into the urethra, should be operated upon. Evacuation of the abscess can be done through the rectum after full dilatation of the sphincter, but operation through the perineum is better. Unless such abscess is evacuated gonococci or other organisms are prone to find their way to other parts of the body. Operation is indicated as soon as tension is present.

Vasostomy for seminal vesiculitis is an operation which has much to offer, particularly in cases in which there is obstruction in the ejaculatory ducts. Belfield (Jour. Am. Med. Assoc., Dec. 25, 1909) showed that the ducts, vesicles, and vas are firm muscular tubes not capable of much dilatation and that when obstruction occurs the infection runs back to the epididymis. Drainage of the seminal vesicles is poor, even when there is no obstruction,

because they empty themselves naturally only at certain intervals. By incising the vas, tension may be relieved, drainage secured, and medication of the seminal tract applied. By this treatment it is also possible to relieve symptoms often attributed to prostatic, bladder, or urethral disease, and disturbances of the nervous system so commonly associated with disease of the prostatic region. An incision is made in the scrotum, midway between the external abdominal ring and the testicle. Through this the vas is brought out, and stripped of all surrounding connective tissue. It is then held between the thumb and forefinger, which are passed behind it, and incised longitudinally with a sharp knife. This incision should be exactly in the middle of the tube and should open its caliber. It may then be sounded for stricture by means of a stiff strand of catgut. Silver nitrate solution may be injected toward the seminal vesicle or epididymis. By this means medication of the vas, the ampulla, the prostatic utricle, and the ejaculatory duct is secured.

If there is infection of the vesicle or vas, the vas should be caught up to the skin wound and left open. The operation then becomes a *vasostomy*. Every day or every second day a mild silver solution may be injected into the vesicle through the opening in the vas. For making the injections a good-sized hypodermic needle, with the point removed and the end rounded, is employed.

When the infection is cured the opened vas may be dissected free from the skin wound and dropped back into the scrotum. Healing without stricture of the vas may be expected.

Vasopuncture for seminal vesiculitis is a method for the introduction of medication into the vesicles through the vas deferens. It is a simple operation and should precede more radical procedures in most cases. The patient should be prepared as for a major operation. The vesicles should be emptied by massage. The vas is identified under the skin, and held between the fingers of an assistant at the neck of the scrotum, while the skin is infiltrated with local anesthetic. An incision 2.5 cm. (1 inch) long, is made through the skin parallel with the vas, and the vas is brought out of the wound. It is denuded of fascia and connective tissue and held over the finger of the operator. Slight traction is made as the needle of the syringe is inserted through the wall into the lumen of the vas (Fig. 1703). The needle should be connected with a rubber tube to give flexibility and prevent injury to the wall of the vas. The needle should then be steadily held while a solution of methylene blue is slowly injected.

This operation should be done with gentleness and care. If there is obstruction in the ejaculatory ducts the fluid will not flow, and the operation should be converted into vasostomy for the sake of drainage. If a catheter has been passed to the deep urethra, and there is no obstruction, the solution will escape through the catheter. The patency of the duct having been determined, the medicinal solution is injected. For this purpose 1 or 2 per cent. silver nitrate may be used. Five or 10 per cent. collargol, 1 per cent. protargol, 10 per cent. argyrol, or other antiseptic may be employed. The injection may be continued slowly and gently until it appears through the urethral catheter. From 2 to 6 c.c. of solution will usually be injected.

When the needle is withdrawn pressure with a gauze sponge should be made at once upon the site of puncture to prevent regurgitation of the fluid and infiltration of the wall of the vas and surrounding tissues. This pressure should be moved along the vas and gently maintained between the puncture and the vesicle for a few minutes while plastic exudate seals the puncture. B. A. Thomas (Surg., Gyn., and Obst., January, 1917) introduced a fine catgut suture in the outer coats of the vas to close the puncture and

prevent infiltration. If infiltration takes place it results in a painful inflammation of the cord.

The fascia over the cord and the skin are closed with a continuous suture of fine chromic catgut. This treatment is highly beneficial in a large proportion of these intractable chronic infections. It is not to be recommended, of course, in acute infections.

Operation for exposure of the seminal vesicles is best done through an incision similar to that employed in exposing the prostate in the perineum. A curved incision is made with its convexity forward, about at the bulb of the spongiosum. The two ends of the incision should be about midway between the anal margin and the tuberosity of the ischium. The prostate is then approached as for prostatectomy. A finger in the rectum serves as a guide. The dissection is carried between the prostate and rectum, laterally upon

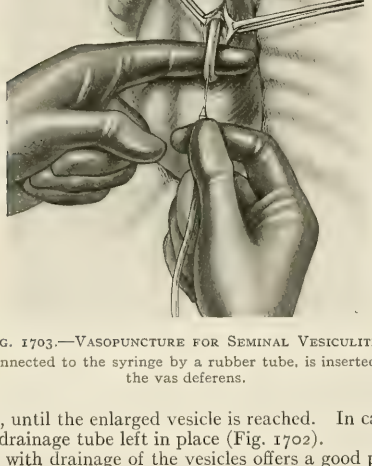


FIG. 1703.—VASOPUNCTURE FOR SEMINAL VESICULITIS.
The fine needle, connected to the syringe by a rubber tube, is inserted into the lumen of the vas deferens.

the affected side, until the enlarged vesicle is reached. In case of abscess, it is incised and a drainage tube left in place (Fig. 1702).

Vesiculotomy with drainage of the vesicles offers a good prospect of relief in chronic infections giving rise to arthritides, pain, septic absorption and nervous symptoms.

This same incision is employed when the vesicle is to be approached for *tuberculosis*. Operation for tuberculosis is indicated only when there is hope of removing all of the disease, which is rarely possible.

If the vesicle is to be excised, a ligature is tied about the upper end and amputation done below the ligature.

In cases of *calculus of the seminal vesicle*, the stone can usually be crushed between a sound in the bladder and a finger in the rectum. If necessary the vesicle may be incised through the rectum.

Seminal vesiculotomy combined with external urethrotomy is indicated in certain cases in preference to either operation alone. In chronic cases of gonorrhea with persistent deep urethritis and vesiculitis, when the ordinary

methods of treatment fail, the vesicles may be exposed and incised through the same wound made for the urethrotomy.

Gonorrhea.—*Gonorrheal urethritis* may be made an obsolete disease if men with gonorrhea would desist from having sexual intercourse with uninfected women. It may be prevented in men by abstinence from sexual contact with infected women. If coitus with a woman other than one's monandrous wife is indulged in, the danger of gonorrhea is very great. Among preventive measures the use of the condom is most efficacious. If such protection is not employed the use of an antiseptic is indicated. For this purpose silver nitrate or one of its proteid analogues is used. A collapsible tube containing about 2 c.c. (½ dram) of silver solution is employed. For this use 1 or 2 per cent. silver nitrate or ½ to 1 per cent. protargol is used. Immediately after coitus the contents of this tube is pressed into the anterior urethra, and retained there a few minutes. An ointment consisting of 33⅓ per cent. calomel and 1 per cent. tricresol in benzoinated lard ("Navy Ointment") is smeared over the glans before coitus. These tubes are a commercial article. Armies and navies provide their soldiers and sailors with them, and by their use morbidity in these organizations has been reduced and much greater sexual liberty enjoyed.

In the absence of the above preventives, cleanliness may be relied upon. Washing the penis well with soap and warm water immediately after coitus is effective. Soap kills the germ of syphilis; it at least inhibits the growth of gonococci; therefore it possesses a chemical value as well as a value as a mechanical cleansing agent.

Before beginning the treatment of gonorrhea an accurate diagnosis should have been made. The patient should be instructed to pass urine in two glasses. The two-glass test determines whether the anterior or posterior urethra is affected and the amount of pus secreted. Microscopic examination of the pus from the uretha should have been made. These observations must be continued during the treatment in order to check up the results. The appearance of complications should be watched for.

For *aborting gonorrhea* in its early stage, while still confined to the anterior urethra and before purulent discharge has begun, the patient may be caused to urinate to wash out the urethra and then the urethra may be irrigated with a tepid 1 : 1000 solution of mercuric oxycyanid. The irrigation should be repeated twice daily with a 1 : 2000 solution for two days, and then once daily until cured. One or two weeks are usually required to effect a cure. Silver solution or protargol injected are also favored preparations. The solution should be brought into contact with the anterior 5 or 8 cm. (2 or 3 inches) of the urethra. By making pressure at the root of the penile urethra, and inserting the injector into the meatus, the infected urethra may be dilated with the antiseptic fluid. It should be retained about three minutes. The treatment may be given once or twice daily for not more than three days if no improvement is secured. If improvement is obtained the treatment may then be given every other day for about two weeks. This method has given the best results in acute urethritis engrafted upon a preëxisting chronic urethritis. The so-called abortive treatment is not effective if the microscopic examination shows that the gonococci are intracellular. It is dangerous if pus is present. In many cases it seems to aggravate the disease, and often to produce complications such as vesiculitis, cystitis, and epididymitis. The danger of these complications is so great that in the author's judgment local intra-urethral applications are not to be advised during the acute stage of the disease, if the simple measures below described can be carried out.

The treatment of *acute gonorrhea of the anterior urethra* demands first that the patient should remain in bed. The diet should be light and simple, such as milk and dry bread. Alcohol and tobacco should be interdicted. Coitus should be forbidden and sexual excitement should be prevented. The bed should be firm and the patient should be encouraged to sleep on the side. If the patient cannot be persuaded to remain in bed a suspensory bandage should support the testicles. The patient should have explained to him the nature of his disease and its dangers to himself and others. This is an important step in the treatment. He should be shown a diagram of the urethra and its accessory organs so that he may have an idea of the possibility of complications. The dangers of drastic measures for securing a rapid cure should be explained. The best way to keep the patient from falling into the hands of the quack is to let him know as much of the disease as possible.

The one most important feature of the treatment consists in keeping the patient quietly lying in bed. Regarding this as the treatment, attention should then be directed to *preventing complications* and making the patient comfortable. *Painful micturition* may be prevented by having the patient drink freely of alkaline water or take 0.6 Gm. (10 grains) of bicarbonate of potash three or four times daily. If pain on urination is very severe it may be prevented by injecting into the urethra five minutes before urination 1 c.c. of 1 per cent. cocain or eucain solution.

The swelling of the urethra may be abated by immersing the penis in a cup of hot water for ten minutes 3 times daily. The glans and the foreskin should be kept clean. A small piece of gauze should be worn at the end of the penis to absorb the discharge. The meatus should be kept lubricated with ointment to prevent drying of secretions. *Chordee* may be prevented by the administration of bromids, camphor, belladonna, hyoscyamus, or other sedative. Hot sitz-baths are also useful.

The patient should be instructed not to touch his eyes with his hands.

A urinary antiseptic should be administered internally. This may be of service in preventing upward extension of the infection. The formaldehyd drugs are irritating to the urethra. *Methylene-blue* is perhaps the most valuable. It may be given in doses of 0.12 to 0.25 Gm. (2 to 4 grains) with a little nutmeg powder or atropin 3 or 4 times daily. Or sandalwood oil may be given in doses of 0.5 to 1 c.c. (8 to 15 minims) thrice daily.

In *acute gonorrhea of the posterior urethra* it is important that the patient should remain quietly in bed. Urethral injections are not to be employed. Hot sitz-baths are of service. The bowels should not become constipated. The internal treatment is the same as for anterior urethritis. Retention of urine may usually be overcome by having the patient urinate while the pelvis is immersed in a hot bath (see Cystitis, page 191). If this fails, aseptic catheterization with a soft catheter must be practised. Bladder tenesmus should be relieved by the free ingestion of fluids, alkaline salts, urinary antiseptics such as methylene-blue, and if necessary the hypodermic injection of sedative drugs such as atropin and hyoscyamin. Rectal suppositories, containing atropin and morphin, may be used. Some of the infusions which are used in cystitis give comfort.

In the *stage of decline* and in cases which do not display sharply acute symptoms, local treatment may be used from the beginning. Injections may be made by a small syringe, using protargol solution (0.5 to 2 per cent.) or argyrol (2 to 4 per cent.). *Injections* may be given every four or eight hours. Before giving an injection the urethra should be washed out by urination. The solution should be held in the urethra five or ten minutes. *Irrigation* of the urethra may be done with larger amounts of fluid, using protargol

or argyrol in 1 : 1000 strength or permanganate of potash solution 1 : 3000. The irrigation should be given at a temperature of 43° to 46°C. (110° to 115°F.).

For giving irrigations the patient should sit well forward on a chair and lean back in a relaxed position. The receptacle holding the fluid should be about 1 meter above the penis. The anterior urethra is first washed out. The tip of the irrigator is then pressed against the meatus and a continuous flow allowed by alternate pressure and relaxation. For irrigation of the posterior urethra, the flow is not allowed to escape, but the patient is instructed to urinate while the fluid is flowing in. This act causes relaxation of the cut-off muscle, and the fluid passes into the bladder. When the bladder is filled, the patient is instructed to pass the fluid; this act gives the final irrigation. This operation should be done every six or eight hours.

In *chronic gonorrhea of the anterior urethra* it is important to eliminate stricture as a causative factor. In this stage a few gonococci may remain, but the desquamative catarrhal inflammation is the main lesion. The general health of the patient should be improved as much as possible. The injection of a weak solution of silver nitrate (1 : 5000) is most effective. There are many antiseptic astringent solutions employed:

	Gm. or c.c.	
Phenol	0.325	(gr. v)
Zinc sulphate	2.0	(ʒss)
Bismuth subnitrate	4.0	(ʒi)
Water	120.0	(ʒiv)

The above is injected with a 10-c.c. syringe.

Hydrarg. chlor. corrosiv	0.008	(gr. 1/8)
Zinc sulphocarbol	2.0	(ʒss)
Boroglycerid (25)	60.0	(ʒii)
Water enough to make	180.0	(ʒvi)

This is more effective in some cases.

Zinc sulphate	0.60	(gr. x)
Resorcin	1.25	(gr. xx)
Water	100.0	(ʒiv)

This solution like the others is astringent and antiseptic.

Alum	10.0	(ʒiiss)
Phenol	2.0	(ʒss)
Water	500.0	(Oi)

This mixture is mildly antiseptic and astringent.

Any of these solutions may be used once or twice daily. They should not be used in the presence of acute inflammation.

Instead of these mixtures, silver nitrate or the proteid salts of silver may be used. Protargol (0.25 to 1 per cent. solution) is much employed. In some cases a weak solution of iodin is of service. These solutions should be retained in the urethra about five minutes. The silver solutions may be used in amounts of about 2 c.c. (30 minims). The injection should not go farther than the bulbomembranous junction.

In making injections in the presence of infection of the urethra the utmost gentleness should be used. It is not safe to force fluids beyond the compressor urethræ muscle. When sufficient force to do this is employed the danger of producing abscess of the prostate and other deep infections is considerable. Forcing fluids past the cut-off muscles into the bladder is not to be recommended in the presence of acute infection. Only when infection has become chronic and nonirritating may this operation be done in its

presence. If it is desired to introduce fluid into the bladder it is best done with a small catheter.

Injections may be made two or three times a day unless they produce pain or irritation, and then the amount used should be reduced and the intervals lengthened. If pain is produced the fluid should be allowed to escape at once. It is retained by gentle compression with the fingers at the meatus. About 8 c.c. (2 drams) should be used at first. This may be increased to 16 c.c. (4 drams). In the stage of decline when the discharge is largely mucoid, the following is recommended:

Any of these solutions may be used once or twice daily. They should not be used in the presence of acute inflammation.

Phenol	0.25	(gr. iv)
Zinc sulphate	1.00	(gr. xv)
Alum	0.5	(gr. viij)
Water	180.0	(℥ vj)

As the discharge diminishes the solution employed should be made weaker and the intervals between injections lengthened.

Small localized patches of erosion or inflammation discovered by the endoscope are best treated by being touched with 2 per cent. silver nitrate solution through the endoscope.

To determine whether gonococci have been destroyed after astringent treatment when the urine has become free from pus, an injection of 1:3000 solution of silver nitrate may be given. If gonococci are present this will cause a discharge of pus in which the organisms may be found.

In *chronic gonorrhea of the posterior urethra* the same general principles of treatment are indicated as in anterior urethritis. Silver nitrate (1:10,000 or 1:5000) solution applied through a small catheter is most effective. The astringent antiseptic combinations, given above, are of much value. The medication must reach the deep urethra, but there is no reason for throwing it into the bladder. By passing a small soft catheter as far as the prostate, and injecting through it by means of a syringe the medicating fluid, the best results may be secured with the least trouble and danger.

A method of treatment which proves effective in many cases, particularly those complicated by neurasthenia, consists in instilling into the deep urethra through a small catheter a few drops of a 2 per cent. solution of silver nitrate.

Ointments are also much used. They are applied through special ointment applicators or through the endoscope. A useful ointment consists of

Iodin	0.8	(gr. xii)
Potassii iodid	4.0	(℥i)
Ol. amygdal	60.0	(℥ii)
Lanolin	60.0	(℥ii)

Silver nitrate is applied in ointment as follows:

Argenti nitrate	1.0	(gr. xv)
Lanolin	90.0	(℥iii)
Ol. oliv	6.0	(℥iss)

Urethral bougies, containing medication held in cocoa butter, are sometimes of service. When gonococci have been destroyed but shreds continue to appear with some mucoid discharge, the passage of a sound (28 or 32 Fr.), large enough to distend the urethra, is useful. This squeezes out the follicles. A daily irrigation under pressure accomplishes the same purpose.

Recapitulation.—Gonorrhea is a very dangerous disease and should be prevented. Local treatment may be employed in the prepurulent stage

but is not to be recommended in the acute stage. Rest is most important.

Before beginning local treatment a tight prepuce or meatus should be operated upon, and stricture should be dilated.

Local treatment of chronic urethritis may be responsible for keeping up a discharge.

Microscopic examinations of the discharge should be made frequently to determine the number and character of cocci.

The marriage of a man, who has gonorrhea, with a healthy women is a crime. Gonococci in some cases may be dislodged by squeezing out the glands by the passage of sounds, and then washing out the urethra with silver solution. Of all the silver preparations, silver nitrate is the most effective. Much of its virtue lies in the hyperemia which it creates. The proteid salts of silver are much employed because of the commercial exploitation behind them.

Antigonococcus serum and *vaccine* are of undoubted value. They have proved their usefulness especially in the gonorrheal infections of other parts than the urethra. In gonorrheal vulvovaginitis they are capable of decidedly shortening the period during which local treatment must be employed.

Neither serum nor vaccine produces immunity. The dosage of vaccine begins with from 10,000,000 to 50,000,000. This should be repeated at short intervals. Maximum doses are 1,500,000,000 of the vaccine and 170 c.c. of the serum. These are enormous doses. Perhaps better results are secured with 2-c.c. doses of the serum given daily for a week, with an intermission of five days at the end of each week. The serum is of value in arthritis. In pure gonorrheal toxemia it is of great service.

Prognosis.—The surgeon should make no prognostic promises in the treatment of gonorrhea. With the best treatment the disease may be most intractable. Usually it may be expected that the gonococci will begin to diminish in number by the end of the third week. So long as improvement continues the surgeon should be satisfied. When improvement ceases the treatment should be changed. It is said that two months should see the end of the disease. No such statement should ever be made. The disease is well when gonococci have disappeared. They may lurk for many months in the follicles and glands only to appear when some irritation is present.

When is gonorrhea in the male cured? In a patient who still has some discharge the discharge should be examined microscopically for gonococci. Examinations of the centrifuged urine is also of help. When there is no longer discharge, an injection into the deep urethra of a 1 or 2 per cent. solution of silver nitrate thirty-six hours before the examination, will produce some discharge. The prostate should be massaged and the seminal vesicles stripped. The secretion thus secured should be subjected to microscopic examination, and if possible to cultural tests. Complement-fixation tests are of value.

The patient may only be regarded as cured when gonococci can no longer be found.

Diplococci, being outside of the cells, and evidently not capable of penetrating the cells, will be found long after gonorrhea has ceased to give symptoms. These cocci are capable of infecting some females, but they do not produce typical and virulent gonorrhea.

Gonorrhea in Women.—The treatment of gonorrhea in women is difficult and unsatisfactory. The woman having contracted the disease from a man, who has contracted it by sexual intercourse with a diseased woman, who had acquired her disease in the same manner from still another diseased man, if she has an idea of the nature of the trouble, she is prompted by shame and

ignorance to desire not to reveal herself as one of the links in the chain of sexual promiscuity and venereal disease, alternating with men and women. She usually defers treatment until the disease has produced discomforts which drive her to the physician for relief.

If she does not know the nature of the disorder, she is not apt to go to the physician until discomfort drives her to it (see Gonorrheal vaginitis, Endometritis, Salpingitis, and Oöphoritis; also Female Genital Organs).

For the *gonorrheal urethritis* the treatment is essentially the same as in the male. Rest in bed, restricted diet, fluids, alkalies, and sitz-baths of hot water should be the main dependence. As the acute symptoms subside, silver nitrate may be applied through the endoscope or by irrigation. If cystitis is present the bladder should be filled with silver nitrate solution (1:10,000) and the solution voided spontaneously. The strength of the solution may be gradually increased. For erosions and local patches of congestion a few drops of 2 per cent. silver nitrate solution should be applied locally. Periurethritis is to be treated by the application of silver solution to the erosion or fissure through which the infection passed. Stricture is prevented by the occasional passage of a dilating sound.

In *gonorrheal vulvitis*, alkaline waters, and potassium citrate will render the urine less irritating. The pudendal hair should be kept cleansed with warm water and free from secretions. A compress of gauze wet with bichlorid of mercury solution (1:5000) should be kept applied to the vulva. This should be changed frequently. Hot sitz-baths should be employed if it is found that they contribute to the comfort of the patient. Boric acid solution should be substituted for the mercury if the latter produces irritation. Silver nitrate (2 per cent.) should be applied to eroded surfaces. A dusting powder of zinc stearate applied on gauze may be laid between the labia.

The treatment of *gonorrheal vaginitis* requires the utmost patience. The vagina should be kept as free from discharge as possible by frequent irrigation. This may be done at least twice daily with bichlorid of mercury solution (1:5000). Twice daily a speculum should be introduced carefully and the whole vaginal surface dried and then touched with silver nitrate solution (1:500). A tampon of gauze, wet with the solution may be left in the vagina. In the course of two weeks the general suppuration ceases and the localized patches of erosion and inflammation which remain should be touched with 2 per cent. silver nitrate solution.

Good results are gotten with a jelly made of 3 parts tragacanth, 2.5 parts alcohol, and 100 parts water containing 1 per cent. silver nitrate. From 3 to 25 c.c. of this jelly are placed in the vagina.

When the vaginitis is very acute the discharge should be washed away by means of a vaginal douche of warm saline solution. No antiseptic medication should be attempted. The douche should be given through a soft catheter. Hot sitz-baths should give relief. As soon as the very acute stage has passed the local treatment may be begun.

The application of sterilized *yeast* to the inflamed vagina has proved effective. It should not be applied to the cervix, and living yeast should not be used.

In *gonorrheal inflammation of the glands of Bartholin* the treatment is operative. If suppuration has not yet occurred the gland and the duct should be excised as a tumor. If an abscess is present it should be incised through the vaginal mucous membrane, and the lining mucous membrane of the sac destroyed by pure phenol. When such an abscess is incised recurrence of an abscess often occurs. The only sure way to destroy the lining is by resection, which may be done at the time of the first operation or deferred until acute

inflammatory reaction has subsided. After packing with gauze the cavity quickly heals. If the gland is chronically infiltrated, resection is the treatment of choice.

The *ointment treatment of gonorrhea* may be applied within the first day after gonococci are found in the discharge. It is possible to sterilize the vagina and cervix with two weeks of treatment. One of the most effective ointments consists of an aqueous solution of protargol mixed with lanolin and petrolatum (2 to 5 per cent.). The vagina is smeared with this ointment. Small bougies may be inserted in the urethra. The bougie is removed when the patient wishes to urinate. A hot antiseptic douche is given 3 times daily.

For *gonorrhea of the uterus* it is important that free exit of discharge is present. If the cervical canal is small it should be dilated. The patient should be kept quietly in bed. A vaginal douche of bichlorid of mercury (1:5000) should be given twice daily. Silver nitrate solution (2 per cent.) may be injected into the uterus once daily through a catheter or tube so loose that it permits ready escape of the fluid.

The treatment of *gonorrheal vulvovaginitis in children* is similar to that described above for vaginitis. The hymen should be divided under cocain. The treatment is best carried out in the knee-chest or lateral pelvic position. The vagina should be washed out with salt solution and then dried. The filling of the vagina with air as the vulva is held open with a speculum best accomplishes the drying. It should be kept open and exposed to the air for half an hour. Then a silver solution of from 0.5 to 2 per cent. should be applied. This drying of the vagina and injection of silver should be practised once daily.

If the drying treatment is not used the vagina should be washed out twice daily with warm salt solution if there is much discharge. Once daily a dram of 0.5 per cent. silver nitrate solution should be injected into the vagina. When silver is used the vagina should first be washed with plain sterile water. If it is found that the silver solution causes no pain its strength should be increased until a 2 per cent. solution is used. The child should be kept quietly in bed. If the size of the vulva will permit, a small speculum may be introduced, the vaginal mucous membrane dried and the solution applied with a tampon. The silver may be applied every second day in mild cases.

The drying treatment, followed by thorough application of the silver, especially to the cervix, gives the best results. If a cure can be established in ten weeks the patient is fortunate. Gonorrheal vaccine has a positive value in the treatment of these cases. The treatment should be controlled by frequent microscopic examinations of the discharge, and should continue until no gonococci can be found on two or three consecutive examinations at the end of a week of no treatment.

Gonorrheal ophthalmia should be prevented by instructing patients with gonorrhea to keep their fingers away from their eyes, by the abolition of the towel used in common in public places, and by the instillation of a 2 per cent. solution of silver nitrate into the conjunctival sac of every newborn child which has passed through a birth canal infected with gonococci.

A patient suffering with gonorrheal ophthalmia should be isolated in a darkened room. If only one eye is infected the other should be protected by a shield. Such a shield may be extemporized by fixing a watch crystal in front of the eye by a circle of adhesive plaster. Attendants should be warned of the nature and danger of infection. The conjunctival sac should be irrigated once daily with warm normal salt solution to wash away discharge. After the irrigation the lids should be everted so as to expose the

lid mucous membrane and the infected surface touched with a tampon saturated with 2 per cent. silver nitrate solution. The application should be made until a white film forms. The film should then be washed away with normal salt solution. This should be done to the upper and lower lids.

If the cornea is not involved in the infection, the swollen eyelids should have applied to them small gauze compresses soaked with ice water. These compresses should be about 4 cm. (1½ inch) square, made of four or six thicknesses of gauze, and kept lying on a cake of ice. One should be laid on the upper lid and one on the lower lid. They should be changed every fifteen minutes.

Extreme swelling of the conjunctiva may be treated by incision into the swollen tissue. This should be followed by irrigation with boric acid solution. In cases of extreme swelling preventing eversion of the eyelid and proper cleansing and drainage, division of the outer commissure of the eye will overcome the difficulty. (See Gonorrheal Conjunctivitis, Vol. II, page 123.)

If there is pain from intra-ocular tension or infection of the cornea atropin should be instilled into the eye. As the swelling subsides the cold compresses may be omitted; and the application of silver may be made at longer intervals as the infection abates. (See also Conjunctivitis Neonatorum, Vol. II, page 122.)

Stricture of the Urethra.—The several varieties of stricture require different treatments. *Congenital stricture* requires early operation. *Acquired stricture* may not need operation. *Spasmodic stricture* commonly subsides without operation. *Inflammatory stricture* in a large proportion of cases disappears as the inflammation and edema of the urethra subside, although it often becomes an *organic stricture* and is cured only by instrumental means.

In passing instruments into the urethra, the patient should lie on the back in a relaxed position. Cleanliness should be observed. The penis, pubes, scrotum and groins should have been cleansed with soap and water. The glans and prepuce especially should be cleansed. The urethra should be washed out with warm boric acid solution. Instruments should be passed with the utmost gentleness. Art, not force, is the principle.

The general condition of the patient is important. Operation should not be done for stricture until the functional integrity of the kidneys has been ascertained. If the amount of urine or urea is subnormal, or there are other evidences of defective function, operation should be deferred until a better action of the kidneys can be secured. The exception to this rule is emergency in which operative relief is required at once.

Before proceeding to treat a stricture, the normal caliber of the urethra should be determined. To find the size of the sound which the urethra will normally accommodate, the following rule may be used: Take the circumference of the penis at about the middle of the organ in millimeters, divide this by 3. The result is the minimum-sized sound in French measure for the urethral canal. Add 3 to this to find the maximum size. Thus: the circumference of the penis is 90 mm.

$$\frac{90}{3} = \text{minimum No. 30 French sound.}$$

$$30 + 3 = \text{maximum No. 33 French sound.}$$

The rule of my former teacher, F. N. Otis, was as follows: When the circumference of the penis is 3 inches the urethra will take a 30 F. sound. With each ⅛ inch increase in circumference a size larger sound is used. Thus, a penis of 3⅛ inches takes a 31 F.; 3¼ inches takes 32 F.; and 3½ inches takes 33 F. Of course the urethra is capable of being stretched beyond this but the

normal caliber of the tube may be said to range between these two figures. (For the Principles of Urethral Instrumentation, Cleansing and Lubrication, see page 183.)

Spasmodic stricture need not be treated by forcible divulsion. The condition often complicates organic stricture. When after a fair trial, the surgeon has failed to pass an instrument through the stricture it is best to desist and give the patient a rest for one or two days, unless emergency requires another course. The patient should be put to bed, the urethra should be washed out, the bowels should be moved freely, and the urine should be rendered unirritating by the administration of potassium citrate. Nervous irritability should be allayed by securing sleep for the patient and by the exhibition of sedative drugs. Before again attempting urethral instrumentation, the urethra should be washed out with warm salt solution, 4 c.c. (1 dram) of 2 per cent. cocain solution should be injected in the urethra and retained for five minutes by holding the meatus closed, and then the urethra injected full of sterile olive oil. An instrument can then usually be passed. In extremely irritable patients, instead of cocain, the operation may be done in the first stage of general narcosis with ether or nitrous oxid. If it is urgent that a spasmodic stricture be penetrated at once, cocain and adrenalin injected against it and retained for ten minutes may cause its relaxation (see Retention of Urine, page 209).

Organic stricture is the common and usually understood condition when stricture is spoken of. It does not heal spontaneously, but naturally tends to contract and grows tighter. *Operative measures* are required for its relief. Anesthesia is usually necessary. Four cubic centimeters (1 dram) of a 2 per cent. solution of cocain injected into the urethra, and retained for five minutes by compression at the meatus, suffices for anesthetization of the anterior urethra. For the passage of sounds, cocain may be used for anesthetization of the deep urethra, but for cutting operations a general anesthetic is desirable. The urethra should be well cleansed and urinary antiseptics should be administered.

There are the same dangers in operating for strictures as have been described for other urinary obstructive conditions. The old, the organically diseased and the infected are apt to develop glandular insufficiency after such operations and die. Before operation, the excretory functions should be brought to as efficient a state as possible. The operation should be short. Shock should be minimized and infection prevented. It is possible for as simple an operation as the passing of a sound to precipitate a fatal attack of kidney insufficiency. For this reason it is important that preliminary examinations shall have advised the surgeon of the patient's condition.

If the passage of an instrument under local anesthesia produces much pain or requires force the surgeon should desist. Persistent efforts under these conditions do much harm. After a stricture has been dilated or divided up to the normal size of the urethra a sound should be passed every second or third day to maintain the full caliber of the urethra. After the second week the sound should be passed twice a week for two or three months, after which it should be passed once a week for two more months, and then once every two or three weeks for two months longer. After this the instrument should be passed every month or two for a year. By this time the patient will have lost interest in his stricture, if he has been faithful in treatment even that long. Nevertheless a sound passed once every six or twelve months is advisable to prevent recurrence. The period devoted to the postoperative passage of sounds may be shortened by careful endoscopic examination. If the urethra is found free from scar and contractile

tissue, soft and pliable, throughout the tract once inhabited by stricture, the passage of sounds may from that time on be foregone.

After the treatment of stricture the urethra should be dilatable up to its full caliber. If the surgeon finds that from time to time he has to reduce the size of the sound, he may be sure that the stricture has not been cured but is in the process of recurrence. It is best to continue treatment until the urethra is dilated to its maximum caliber, or even one or two sizes larger than that.

Operations for stricture are required in all cases of the organic variety. Before any operation is done the meatus should be found to be dilatable to the maximum caliber of the urethra in order that the proper sounds may be introduced. If it will not admit a sound of the maximum size the operation of *meatotomy* should be done. After cleansing the glans and washing out the urethra, a pledget of gauze saturated with 5 per cent. cocain solution is placed in the urethra at the meatus. This should reach about 2.5 cm. (1 inch) into the urethra. It should remain in place five minutes and then be replaced by a second application for the same length of time. If it is necessary that there should be no pain, a few drops of cocain solution should be injected with a needle through the anesthetized mucous membrane into the frenum at its extreme end. The glans penis is then grasped between the thumb and index-finger of the left hand, steadying it and at the same time retracting the foreskin. A slender knife incises the meatus and floor of the urethra for a distance of about 1.3 cm. (½ inch) up the urethra. The incision should be exactly in the middle line, and should enlarge the meatus sufficiently to take a sound of the maximum size but no more. A piece of gauze 2.5 cm. (1 inch) long, well smeared with ointment, should be introduced into the urethra to prevent healing together of the wound and failure of the operation. Once daily for ten days a sound should be passed through the meatus and the ointment reapplied. Firm organic strictures in the penile urethra are best treated by internal urethrotomy as they are prone to recur after dilatation alone.

Gradual dilatation is the operation of choice applicable to the majority of organic strictures. It is indicated in recent strictures, in strictures which are dilatable, in strictures which do not involve the circumference of the urethra, and in strictures aggravated by irritability. The operation is less hazardous than urethrotomy, and is therefore to be preferred in the aged and debilitated.

In *strictures of large caliber*, after washing out the urethra, a steel sound (Fig. 1598) one size smaller than the stricture, should be passed. The sound should be introduced until its full thickness has passed through the stricture. It should remain in place a few minutes and then be withdrawn. If the urethra is highly congested or if there is a zone of swelling in the region of the stricture adrenalin may be injected before passing the sound. If there is much discomfort the instrument should not be left *in situ*. The next sound should fit snugly. The operation should be repeated in about five days. Each time a size larger sound should be used. The treatment of chronic urethritis should go on in company with the treatment of the stricture. A sufficient interval should elapse between each dilatation to allow the urethra to recover from whatever traumatism is caused. Dilatation once a week is usually often enough. The passage of sounds should continue for about three months. After the first few times the sound should be allowed to lie in the urethra for five or ten minutes before its withdrawal. If there is bleeding or other evidences of severe traumatism, the injection of adrenalin should precede the operation, and the urethra should be filled with oil before

the sound is introduced. When dilatation has been carried up to the maximum caliber of the urethra, endoscopic examination may show that the stricture is no longer present. If there remains still some appearance of induration the passage of sounds should be continued at monthly intervals for a year or longer. Later by passing a sound every six months, recurrence may be prevented.

Instead of using sounds, the dilator which s operated by a screw may be employed. The dilator of Kollmann is most used. This instrument is passed through the stricture and dilated up to the point of meeting firm resistance. It requires less skill than the sound. Usually at each operation the instrument may be screwed up two or three points more than at the previous operation.

In *filiform strictures* the surgeon is not able to pass a sound but a passage must first be found by means of a filiform bougie or ureteral catheter (Fig. 1704). The flexible French bougie is safer in the hands of the inexperienced. The best instrument is the whalebone bougie. The whalebone bougie should have a slight bulge at the tip, but even with this, it is capable of doing harm by making a false passage. A filiform bougie should not be passed soon after

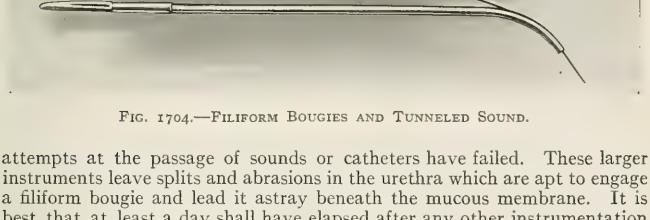


FIG. 1704.—FILIFORM BOUGIES AND TUNNELED SOUND.

attempts at the passage of sounds or catheters have failed. These larger instruments leave splits and abrasions in the urethra which are apt to engage a filiform bougie and lead it astray beneath the mucous membrane. It is best that at least a day shall have elapsed after any other instrumentation before the passage of a filiform is attempted.

The presence of a filiform stricture being known, preparation for a serious operation should be made. The patient should come to the operating table in the best possible general condition. Urinary antiseptics should have been administered. The urethra should be washed out. Four cubic centimeters (1 dram) of 2 per cent. cocain solution is injected into the urethra and retained there for at least five minutes. Then it is allowed to escape. An endoscope is then inserted and the mouth of the stricture discovered by sight. A ureteral catheter, having the opening at its tip, is then passed into the mouth of the stricture and adrenalin and cocain solution injected. After a few minutes it may be possible to pass the catheter still further and inject more fluid. When the catheter has passed through the stricture, it may be withdrawn and followed by a filiform bougie. Oil may then be injected and more filiforms inserted.

If this method is not pursued, the urethra may be injected with sterilized olive oil after the cocain solution. The fingers of the left hand grasp the penis behind the head and the right hand gently conducts a filiform bougie into the urethra. It should follow the floor of the urethra until it reaches the stricture. If it does not pass through the opening it should be withdrawn

a short distance and again passed toward the stricture. By gentle manipulation the opening may be found. The utmost gentleness should be used. If the bougie does not pass through it should be left *in situ* and a second one should be introduced beside it. If this does not pass through the stricture, more bougies should be introduced until six or more are in the urethra all resting against the stricture. By rotating and manipulating one after another of these, one will often be found which enters the passage.

If the patient becomes fatigued or irritable, if bleeding is pronounced, or if a false passage is entered, the bougies should be withdrawn and the patient put back to bed for at least a day, before another attempt is made.

A bougie having passed through the stricture, more oil should be injected and a tunneled sound passed over the filiform which serves as a guide. The sound should be the smallest size. The tunneled sound should be passed through the stricture. If its passage was not difficult the next size larger should then be used. The patient should then be put back to bed, urinary antiseptics continued, and quiet enjoined. After two or three days a filiform bougie should be inserted, and a sound, a size smaller than the last, passed. This should be followed by increasing sizes until some resistance is met, or until a sound two or three sizes larger than used at the last sitting is passed. The operation should be repeated about every third day until a 16 F. or 18 F. sound can be passed. After that the filiform bougie may be omitted the stricture may be regarded as of large calibre and gradual dilatation with sounds practised until it is cured.

In cases of *impermeable stricture*, in which a filiform bougie cannot be passed, the injection of adrenalin against the stricture may cause contraction of the swollen tissue and permit its passage. By injecting the urethra full of glycerin a filiform may follow it through the stricture. In other cases by passing an endoscope down to the stricture the orifice may be found by direct vision. Then a ureteral catheter may be inserted and cocain and adrenalin injected, as described above.

When the passage of instruments causes troublesome hemorrhage, spasm, irritation of the bladder or other constant disturbances, further attempts should not be made. In cases in which the filiform cannot be inserted or in which passage of the tunneled sound cannot be effected, the case should be treated as one of impassable stricture.

Continuous dilatation may be employed in cases in which difficulty has been experienced in getting a filiform bougie through a stricture, and further gradual dilatation is inexpedient. In such cases the filiform may be left in the urethra. If possible one or more additional filiforms may be left in side by side, or a small catheter having an eye in the end may be left *in situ*. If filiforms are employed urine will dribble away alongside of them.

In some cases of larger, firm stricture or stricture associated with spasm or edematous swelling, a rubber catheter left in the urethra for a day or two will facilitate later gradual dilatation or internal urethrotomy. In such cases if perineal urethrotomy becomes necessary a guide is ready in place, which serves both for entrance to the bladder and for posterior attack upon the stricture.

Rapid dilatation is practised in the case of soft strictures of the penile urethra. It consists in passing sounds, as for gradual dilatation, one after another at one sitting until the desired degree of dilatation is secured. Lubrication should be thorough and every care to save the mucous membrane should be exercised. Instead of sounds, a screw dilating instrument may be used. The dilatation should be done slowly, and should not constitute di-

vulsion. The operation should be followed by the occasional passage of sounds as for the other operations.

The operation in skilled hands is also applicable to *filiform strictures of the bulbomembranous urethra.* The experienced surgeon almost invariably can pass a filiform bougie through these strictures. The operation may be done as a curative procedure; it may be performed as a primary step in gradual dilatation; or it may be done to facilitate the passage of a guide for the performance of perineal urethrotomy. The preparation of the patient should be carried out conscientiously. The bowels should be emptied, and it should be known that the kidneys are excreting well. The patient should be anesthetized, the urethra well washed out, and filled with sterile oil. A filiform bougie is then passed through the stricture to the bladder. Over

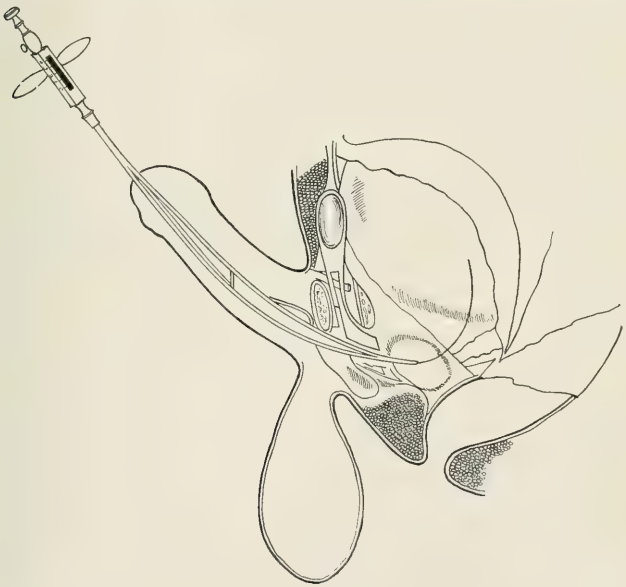


FIG. 1705.—DILATOR AND FILIFORM BOUGIE IN BLADDER.

this as a guide a small dilator is threaded. The best intrument for this purpose is the curved dilator of Thompson (Fig. 1705) which measures 7 mm. at the tip and 11 mm. at the shaft, and is capable of being dilated to 22 mm. It has a hole at its tip through which the filiform passes.

The operation of passing the dilator over the bougie requires gentleness and skill. The dilator should be caused to slide over the filiform the latter being held steadily until the dilator reaches the stricture. At this point the filiform should no longer be held apart from the dilator but should be withdrawn a short distance and then held by the same hand which holds the dilator. The dilator should then be caused to advance through the stric-

ture, carrying onward with it the filiform bougie. The passage of the dilator through the stricture can be done well only by a surgeon of skill and experience in urethral instrumentation. As the curve of the urethra is met the handle of the instrument is depressed, and the beak passes onward to the bladder. Entrance into the bladder is announced by escape of urine at the sides of the instrument.

The stricture is dilated by slowly screwing apart the blades. This should be accompanied by alternately screwing and unscrewing, causing stretching and relaxation of the stricture. The dilatation should begin posteriorly, and as it proceeds the instrument should be withdrawn, thus dilating from behind forward. When the instrument has been dilated to its full capacity, it should be withdrawn with the bougie and a larger dilator, such as that of Kollmann introduced. With a dilator capable of further dilatation, the full size of the urethra should be restored. The screwing up of the instruments should be gradual, and alternating with relaxation. When the maximum size of the urethra has been attained, the instrument should be screwed down to its minimum size and withdrawn. A steel sound should then be passed in order to make sure of the success of the operation. Before the passage of each instrument the urethra should be filled with olive oil. If satisfactory dilatation has not been secured, the dilator should again be brought into action.

Having secured a restoration of the urethral caliber, the urethra should be washed out and a soft rubber catheter passed to the bladder. This should be fixed in place (see page 222) and left for three days. When it is removed a steel sound should be passed. The passage of the sound should be practised, as in the treatment of gradual dilatation, at first twice a week and then with lengthened intervals. Urinary antiseptics should be exhibited while the catheter is in place. Before the catheter is removed the bladder should be filled with boric acid solution, which should be voided to wash out the urethra after withdrawal of the catheter.

This same operation of rapid dilatation is applicable also to strictures of the penile urethra.

Internal urethrotomy is performed in the cases of stricture of the penile urethra which because of resistance or irritability are not suitable for gradual dilatation. It is also practised in cases in which the passage of sounds through a tight stricture persistently causes chills, fever or other serious disturbances. It is of most utility in strictures of the lower 5 cm. (2 inches) of the urethra. The operation was once the routine method of treatment of all strictures. It has steadily fallen into disuse until now many surgeons have abandoned it. The operation often produces troublesome bleeding. Fatal hemorrhages have not been uncommon. Deformity of the penis, as a result of infiltration and contracture, often occurs. The operation can be done only when an instrument can be passed through the stricture; and in cases in which this can be done, dilatation can be practised and internal urethrotomy is rarely necessary.

The instrument employed is the dilating urethrotome invented by Fessenden Otis. It carries a thin knife which sinks into a slot and rises out of the slot when drawn upon (Fig. 1706). The urethra should be washed out and the stricture accurately located by means of the bulbous urethrometer or bulbous sounds. The surgeon should know the distance from the meatus of both the upper and lower limits of the stricture or strictures. Under cocain or general anesthesia the urethrotome is inserted. It is passed in the urethra, with the knife in the median line upward or backward, until the knife is above the stricture. This is determined by the measuring workings on the

instrument. It is then expanded by turning the screw until resistance is met. No effort should be made to divulse the stricture. The knife is then withdrawn a distance equal at least to the breadth of the stricture, and pushed back so that it sinks into its pocket. The dilator is screwed up two points beyond the maximum size of the urethra, then screwed down and removed. If there is resistance to the dilatation, the knife should again be brought into play. There seems to be no choice between incision of the roof and of the floor of the urethra. The latter is perhaps, the least objectionable. In multiple dense strictures both roof and floor may be incised.

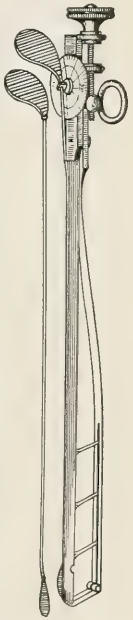


FIG. 1706.—DILATING URETHROTOME OF OTIS.

The instrument is opened. An extra knife is shown.

After removing the urethrotome, a maximum-sized steel sound lubricated and in readiness is passed to the bladder. The urethra and bladder should be washed free of clots. Two small padded splints should be put on either side of the penis and held with elastic bands to make gentle pressure. If the hemorrhage seems severe it is better controlled by passing a maximum-sized rubber catheter into the bladder and leaving *in situ* for two days. If such a catheter is not at hand a sound may be left in the urethra. The patient should be given urinary antiseptics and kept in bed. Every second or third day a sound should be passed. This operation should continue as for gradual dilatation. All stages of the operation should be conducted with the utmost regard for cleanliness. The urethra should be kept up to its normal size by dilatation.

In *strictures of small caliber*, dilatation by means of a smaller dilating instrument, such as the Thompson dilator must first be secured.

In *deep urethral strictures of small caliber* which are elastic or irritable gradual dilatation may not be effective, and internal urethrotomy is of service. Internal urethrotomy alone in these cases is unjustified because of the danger of infection, hemorrhage and secondary kidney insufficiency. External urethrotomy also should be done. A filiform bougie, followed by rapid dilatation with the dilator of Thompson, enlarges the stricture up to a size which will receive a dilating urethrotome. This should be passed immediately after the dilating instrument is removed. The urethrotome should be screwed up until the resistance of the stricture is met, but no farther. The stricture should be divided on the floor of the urethra. The instrument is then withdrawn and a steel sound inserted. The patient, having been prepared for perineal operation, is then placed in position, and perineal urethrotomy done. Some surgeons prefer to pass a grooved staff as soon as sufficient dilatation has been secured, perform perineal urethrotomy, and then divide the stricture.

The urethra and bladder should be washed free of clots and a full-sized rubber catheter fixed in the urethra to insure permanent drainage. This should be removed every two or three days, the urethra washed out and a steel sound passed. A clean catheter should be replaced. Permanent drainage may be maintained if the patient tolerates the catheter well, until the perineal fistula is healed. The catheter may if necessary be removed and left out any time after the first two days without fear of urinary infiltration.

The above treatment constitutes *combined internal* and *external urethrotomy*.

In *filiform strictures* it is often impossible to introduce a bougie through the stricture by any of the expedients described above. Direct vision may be employed to locate the stricture. This is accomplished by the endoscope. If a good sized endoscope is introduced in the urethra, the infundibuliform site of the stricture can be seen. In some cases the opening may be found laterally or concealed under a fold of mucous membrane. But by careful manipulation of the tube and sponging or irrigation the little black spot, representing the opening, can be located. By the aid of vision the filiform bougie is passed into the opening. When it is found that the bougie traverses the stricture, the endoscopic tube is withdrawn, and the next steps in the dilatation or division of the stricture proceeded with.

In *impermeable strictures of the anterior urethra*, the penis may be grasped and steadily held while a long, thin, straight, narrow-bladed, sharp-pointed bistoury is passed into the meatus and through the constricting tissue. With care and patience the urethra above the stricture may be entered and dilating instruments then passed. If the stricture is quite extensive it is best to begin the operation with a perineal urethrotomy. Through the perineal wound a sound is passed down to the upper side of the stricture. The long bistoury, passed through the meatus, then seeks the end of this sound. It will often happen in these cases that a filiform bougie passed from above can be made to find a passage through the stricture, and then rapid dilatation may be employed.

In *impermeable stricture of the deep urethra* perineal urethrotomy should be done. A sound or a urethral guide is passed into the anterior urethra until it impinges upon the stricture. This is held steadily by an assistant, while from above, operating through the perineal wound, the surgeon cuts through the stricture with a small knife toward the tip of the sound. The stricture is then dilated up to the maximum, and drainage by a perineal tube or by an in-lying catheter provided. Sounds should be passed beginning with the second day.

If there is not much scar tissue, after incision of the stricture a catheter may be placed in the urethra, and the urethra sutured over it.

In these cases it is often possible to introduce a bougie through the stricture from above. This may be done through a suprapubic cystotomy. Or a trocar and canula are plunged into the distended bladder, the trocar removed and the bladder washed out; through this as an endoscope, a filiform bougie is passed into the urethra under direct-vision illumination. The filiform may serve as a guide for passing a rubber catheter or other instrument.

A more simple procedure for tracing a fine canal through a stricture is by the use of methylene blue. A solution of pure methylene blue is made in distilled water. It should be about 5 : 1000 (0.5 per cent.) strength. The solution is injected into the anterior urethra, gently at first and then with slight force. Too much force may cause it to close the canal or penetrate the urethral wall. The urethra below the stricture is then washed out with clear water, a sound passed to the stricture, and the urethra incised in the median line down to the tip of the sound. The sound is removed, and the wound retracted. It will then be found that the narrowed canal can be traced through the stricture by the blue color. It may be divided with knife or scissors.

External urethrotomy is performed usually through the perineum. It is done preferably with a guide, but when a guide cannot be passed it may be

done without one. In many of the conditions described above, perineal urethrotomy is a safer and more satisfactory operation than dilatation or internal urethrotomy alone. It has the merit of providing drainage where drainage is most needed.

The operation is indicated in all strictures posterior to the penile urethra, strictures in the region of the bulb, impermeable strictures in any part of the urethra, and strictures associated with urinary fistula or peri-urethral abscess.

The patient should be placed in the elevated-pelvis perineal position (see Perineal Cystotomy, page 217). The scrotum should be elevated by being enveloped in a sling made of a moistened towel. A small, curved,

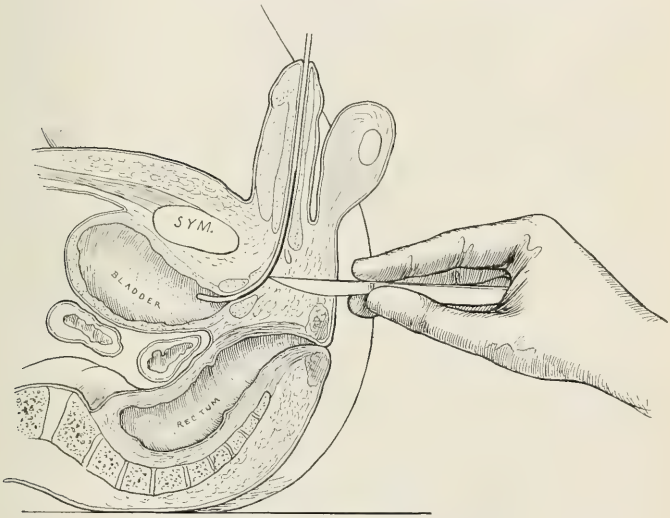


FIG. 1707.—PERINEAL URETHROTOMY WITH THE AID OF A GROOVED STAFF.

grooved staff or tunneled sound is introduced into the urethra and held by an assistant so that its convexity causes the urethra to press against the perineum. In the case of deep strictures the curve of the staff tends to push backward the stricture so that it is caused to bulge against the perineum. An incision is made in the median line, as for median perineal cystotomy, from the base of the scrotum to a point about 1.3 cm. (½ inch) anterior to the anus. The urethra is exposed, and opened by a longitudinal incision. Its edges are grasped by fine clamps, or each edge caught with a silk suture, and entrusted to the hands of the assistants for retraction (Fig. 1707). If there is a stricture, a long narrow- (5-mm.) bladder knife is then passed directly into the groove of the staff with its back upward and its cutting edge down. As its point rests in the groove it is pushed straight backward to the bladder. In the case of deep stricture, the stricture is felt to be divided before the knife reaches the bladder. The sphincter of the bladder should not be cut unless it is involved in the stricture (Fig. 1708).

A straight grooved director, or gorget, is passed through the perineal wound into the bladder. The curved staff is removed. A maximum-sized sound is passed through the urethra to demonstrate its freedom from stricture. A soft rubber catheter is then passed through the urethra and upon the grooved director as a guide into the bladder. The director is then removed. If it is removed sooner difficulty in guiding the catheter into the bladder may be experienced. The catheter is made fast to the penis and fixed for continuous drainage. The perineal wound should be partly closed at either end by sutures.

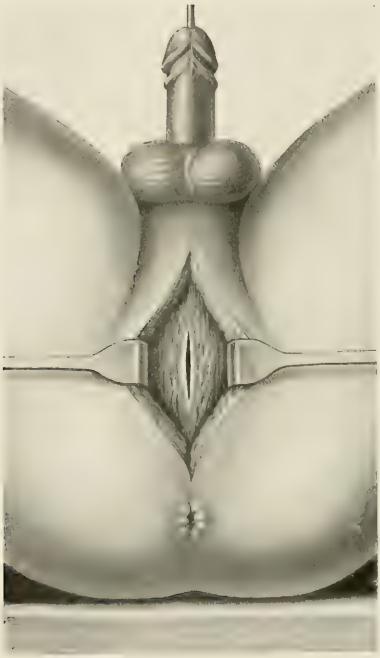


FIG. 1708.—PERINEAL URETHROTOMY.
The wound is held open with retractors. The urethra is incised.

If the catheter is not well tolerated, a tube for bladder drainage may be brought out through the perineal wound. Drainage by catheter or tube should be continued for three or four days, after which a maximum-sized sound should be passed throughout the urethra every second day until the perineal wound is healed. The sound should then be continued at intervals as described for gradual dilatation.

A *simplified external perineal urethrotomy* was devised by J. D. Barney

(Surg., Gyn. and Obst., February, 1918) for diverting the urinary stream in cases requiring operation on the penis such as for hypospadias and epispadias. The patient is prepared for perineal urethrotomy, and a well-lubricated soft-rubber catheter is passed through the urethra into the bladder in the usual manner. The catheter should be inserted until the end is almost at a level with the external meatus. The catheter is then grasped 0.5 cm. from its end with a curved clamp. This clamp should have the curve of a sound, and be small enough to pass into the urethra. The clamp, grasping the catheter, is then passed up the urethra, its convexity against the roof, until its tip is felt pressing against the bulb. This procedure causes the catheter to pass on and become coiled in the bladder. The tip of the clamp is then caused to press against the perineum, bulging it downward in the median line. The urethra is then opened at this point by an incision not larger than 1 cm. long, and the end of the clamp exposed, holding the end of the catheter. The catheter is released, by opening the blades of the clamp, drawn out through the wound, and the clamp removed. The catheter is drawn out through the wound until its eye lies at the proper position in the bladder. A stout ligature around the catheter and through the wound completes the operation.

In *cases in which a grooved staff cannot be introduced* to the bladder, but a filiform bougie can be passed through the stricture, the bougie should be carried to the bladder and a tunneled guide passed over the filiform as far as the stricture. The surgeon then has located the stricture and the urethral passage to the bladder. The stricture is cut down upon by causing the tip of the guide to press downward against the perineum (Fig. 1709). Having entered the urethra and divided the stricture, the filiform serves as a guide by which to pass a director into the bladder. A sound is then passed the length of the urethra, and the treatment continued as above described.

In *impermeable stricture* a grooved, curved guide is passed down to the stricture and held steadily in the median line by an assistant. The tip of the director is pressed downward so as to press against the perineum. Toward this as a guide the surgeon makes his incision in the middle line of the perineum. The urethra is opened above the stricture. The dissection is then carried through the stricture to the tip of the guide. Often after opening the urethra, a fine probe or bougie can be passed through the stricture from behind.

In deeper strictures the urethra can be opened distal to the stricture. This being done, silk loops, for retraction purposes, are placed in either side of the urethra where it is opened, and a fine probe or bougie passed through the stricture to the bladder. Upon this as a guide the stricture is divided, the cutting edge of the knife being toward the floor.

In *operating for impermeable stricture without a guide*, as is done in cases in which penile strictures prevent the passage of a guide, and in multiple strictures, wounds, and distorted conditions of the urethra, it is important that all of the aids for centralization be employed. The patient should be placed squarely upon the table, the elevation of each leg should be the same, retractors should be held with reference to same relative positions and the same amount of traction upon each side. If care is given to these details, it is not difficult to open the urethra through the perineum without a guide; but if attention is not given to them the surgeon will be seen dissecting to one or the other side of the urethra or vainly trying to find a urethra that is covered by a retractor.

Some surgeons operate for impermeable stricture with the left index finger in the rectum, its apex against the prostate. This helps as a guide to find

the median line, and prevents wounding the rectum. Access to the interior of the urethra should be secured by deliberate dissection by means of sight in a dry field. Sweeping and plunging incisions in a bloody field are to be deprecated.

Having gained access to the urethra and divided the strictures, the treatment is the same as described above.

In *stricture with obliteration of the deep urethra* by scar tissue (*dense obliterating stricture*), the urethra is found at one or the other end of a fibrous

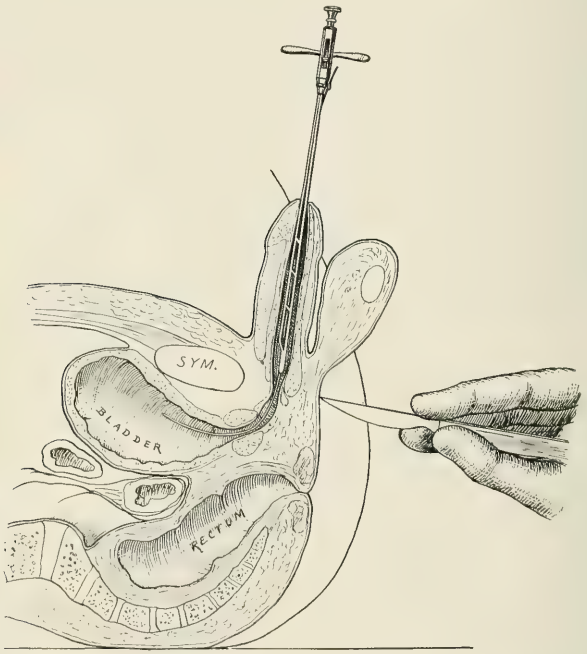


FIG. 1709.—OPERATION FOR STRICTURE OF THE URETHRA WITH FILIFORM BOUGIE AND TUNNELED SOUND.

The bougie passes through the stricture. The dilating tunneled sound is stopped at the stricture. The bougie serves as a guide.

mass. The surgeon should make his dissection with supreme regard for the median line until the urethra is incised. It is best to seek for the urethra in the direction of the bladder. When it is found a gush of urine will signalize its incision.

In such cases it is best to dissect out the scar tissue, as though it were a tumor, leaving any mucous membrane which may be found in it and bringing together with sutures as well as possible the ends of the urethra. A catheter

should be left in the urethra or a tube brought out through the perineal wound (see Wounds of the Urethra, page 271 and Urethrectomy, page 300).

In the case of *stricture with false passage*, caused by ignorant or brutal instrumentation, perineal section should be done as soon as possible because of the danger of extravasation of urine and serious infection. The stricture, if deep, should be divided in the perineal wound; if anterior, it should be penetrated and divided or dilated from behind.

In *stricture with infection of urethra* and *bladder*, giving rise to serious inflammation, relief of the obstruction is necessary for the cure of the inflammation and to prevent its extension upward. Internal urethrotomy or dilatation should not be done in the presence of purulent infection. Perineal urethrotomy should be performed, and direct drainage of the bladder secured by a tube fixed in the perineal opening. Drainage of the bladder being established, the urethritis and cystitis should be treated by irrigation. Later any stricture which remains uncured may be treated after the infection has been overcome.

Cases of *stricture with retention of urine* should be treated for the retention; that is always urgent, the stricture is not (see Retention of Urine, page 209). The retention having been relieved the stricture may be treated at an opportune time.

In cases of *stricture with fistula*, much induration by scar tissue may be expected to be found as the result of the abscess which gave rise to the fistula. If there is no acute infection, the stricture should first be treated. Usually the fistula will heal when the stricture is cured. If there is much deposit of scar tissue it may be dissected out. A fistulous tract should be curetted (see Fistula, Vol. I, page 304).

In stricture with extravasation of urine, the extravasation is accompanied by wound of the urethra or infection and cellulitis. It is an extremely serious condition. The imperative demand is for drainage of the bladder and removal of the urinary current away from the perforated urethra. Perineal urethrotomy is usually to be done at once. The fact that the perineum may be infiltrated with urine is not a contraindication but an indication for perineal section. Drainage of the bladder should be secured by means of a tube through the perineal opening. Every precaution should be taken to avoid infection. The area of subcutaneous infiltration should be kept covered with a gauze dressing wet with antiseptic solution.

Prostatic urethrotomy is employed when the urethra cannot be found. The operation proceeds as for prostatectomy. The median wound is deepened or a transverse incision is added to it so as to give ample room. The apex of the prostate is exposed. The urethra is sought as it emerges from the prostate and is opened. A filiform bougie or catheter is then passed from the opening at the prostate forward and the position of the urethra thus identified.

Retrograde catheterization through a suprapubic opening is done in cases in which time cannot be taken to find a distorted urethra by the perineal route. This is often the case in debilitated patients with infiltration of urine with gangrene, cellulitis or uremia. It is also employed in traumatic rupture of the perineal urethra, in rupture of the urethra with distorting stricture, and in cases of obstructive hypertrophy of the prostate with deep stricture. In such cases as these if perineal incision fails in discovering the urethra, no time should be lost in performing suprapubic cystotomy and retrograde catheterization. The operation may rarely become necessary

in rupture of the urethra when the distal end but not the proximal end can be found.

In such cases suprapubic cystotomy may be done under local anesthesia (page 214). This provides urinary drainage. If the operation is done for retention it is not necessary to proceed with the perineal operation; but after a few days it may be found that the stricture has become permeable, and may be treated by the ordinary anterior methods. When it is desired to locate an impassable stricture, a suprapubic opening large enough to admit the index-finger is made. The finger identifies the internal urinary meatus. Along the finger acting as a guide, a sound is passed into the urethra through the bladder. It is arrested at the stricture. Another guide is then passed down to the stricture through the anterior urethra. The tips of these bulge into the perineum, holding the stricture between them. It is a safe and simple matter to cut down through the perineum upon the stricture with both the proximal and distal urethras identified.

The internal meatus may also be found by suprapubic puncture with a large trocar and canula. The trocar is removed. The canula is used as an endoscope, or an endoscope may be introduced through it. The end of the tube is inserted into the internal meatus, and a bougie or catheter passed as a guide. This permits retrograde catheterization without cystotomy.

Urethrectomy is performed for tumors of the urethra and for dense cicatricial masses usually in the deep urethra. The former is very rarely required, the latter very commonly. The stricture masses usually requiring resection are old traumatic strictures and strictures which have been associated with abscesses and sinuses. Resection is indicated when the stricture mass is impassable or when repeated attempts at cure have been followed by recurrence. The mass of scar tissue should be cut down upon in the middle line, and the urethra at each end sought for. The scar mass should be dissected out, leaving if possible a strip of urethra on the roof to continue across the gap. Every effort should be made to preserve some continuity of the mucous membrane. If such *partial urethrectomy* can be done a catheter should be left in the whole length of the urethra for bladder drainage and the wound closed over it.

If *complete urethrectomy* must be done, enough of the urethra on the roof, at least should be left long enough to bridge the gap. A gap of 2.5 cm. (1 inch) is the widest that can be approximated. A narrower gap is more easily closed. It is best sutured with fine chromic catgut, the knots being tied outside of the urethra. Some stay sutures should be placed in the peri-urethral tissue. A catheter should be placed in the whole length of the urethra and fixed.

If the resection requires the removal of so much of the urethra that the gap cannot be closed, it is possible to transport mucous membrane from the circumcised foreskin or from some other place. A piece of resected vein, vermiform appendix, or a tube of skin may be implanted in the gap. In the event that the gap cannot be bridged, the approximation should be made as good as possible, the peri-urethral tissue should be closed in smoothly and a catheter passed through the meatus to the bladder and fixed in place. Mucous membrane may be expected to grow across a gap of 1.25 cm. (½ inch). In the case of a larger gap, the distal end of the urethra may be closed, the proximal end sewed to the lower part of the wound, and the wound closed about it. Urine is voided through the shortened urethra, the inconveniences being that urination must be done in the sitting position and normal ejaculation is impossible.

THE TESTICLES AND SCROTUM

Anatomy.—*The scrotum* contains the testicles and spermatic cord. A median raphé divides it into two parts. The left half is lower than the right. The left spermatic cord is longer than the right.

The *spermatic cord* begins at the internal abdominal ring, passes through the inguinal canal, and ends at the testicle. It is made up of the *vas deferens* with its vessels and nerves, the spermatic vessels and nerves, the sympathetic nerves, the cremasteric artery, the genital branch of the genitocrural nerve, lymphatics and areolar tissue. After emerging at the external inguinal canal, it lies in front of the pubes and thence passes into the scrotum.

The *vas deferens* conveys the spermatozoa from the testicle to the seminal vesicle; it is situated at the back of the cord and may be distinguished by its firm, cord-like feeling (Fig. 1710). It is 40 to 50 cm. (15 to 20 inches) long and passes upward from the scrotum, through the inguinal canal into the abdomen behind the peritoneum. It curves downward into the pelvis to the angle between the bladder and rectum where it becomes dilated into an ampulla, which is internal to the seminal vesicle. The seminal vesicle unites with it to form the ejaculatory duct. The vas crosses to the inner side of the external iliac artery.

The *seminal vesicles* are two elongated pouches lying at the base of the bladder to the outer side of the vasa deferentia (see Bladder, page 182).

The testes are two egg-shaped glands, suspended in the scrotum by the spermatic cord, which is connected to its posterior surface. The main part, or body, of the testicle contains the seminiferous canals which secrete the spermatozoa and which are collected into lobules separated by septa of connective tissue. These canals unite to form *straight tubes* which are collected at the mediastinum, from which ten or fifteen *vasa efferentia* pass to the *epididymis*. The *vasa efferentia* radiate from the mediastinum to empty into the single canal which constitutes the body and tail of the epididymis. This tube is 10 to 20 feet long. It is much convoluted until it reaches the posterior aspect of the junction of the body and tail, where it straightens out and becomes the *vas deferens* (Fig. 1711).

The testis is supplied by two arteries. These are the spermatic, a branch of the aorta, and the artery of the vas, a branch of the superior or middle vesical artery. These anastomose freely and either one may be sacrificed in operations for varicocele. The spermatic artery lies anteriorly. It is surrounded by an anastomosing group of veins. This anterior plexus is most dilated in cases of varicocele. These veins empty on the left side into the left renal vein and on the right side in the vena cava. The posterior group of veins anastomose freely with one another. They empty mostly into the deep epigastric veins. The vas deferens lies between the two groups of veins accompanied by the artery of the vas. The posterior group of veins is not much affected in varicocele, so that operation for that condition usually removes the anterior group with the spermatic artery and leaves uninjured the posterior group with the vas and its artery.

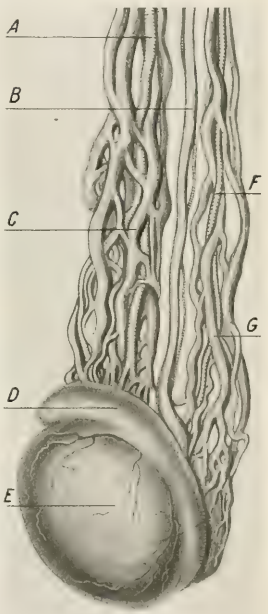


FIG. 1710.—SPERMATIC CORD.

A, Spermatic artery; *B*, vas deferens; *C*, anterior group of veins; *D*, epididymis; *E*, testicle; *F*, cremasteric artery; *G*, posterior group of veins.

THE SCROTUM

Wounds of the scrotum should be treated first by shaving the hair in the region of the wound. If the wound is infected it should be sutured with provision for drainage; if not infected, drainage is not necessary. Wounds,

in which the deep fascia is divided and prolapse of the testicle has occurred, should be treated by replacing the testicle and suturing the fascia and the skin. Punctured wounds should have provision for drainage. A copious dressing of gauze, wet with mild antiseptic solution, is the best application.

Hemorrhage into the scrotum, if there is enough blood to make a palpable mass, should be treated by incision and evacuation of the clot. The bleeding vessel may be caught and ligated, or if no vessel can be identified the wound may be packed with gauze. Slow oozing may be controlled by compression and cold. Hemorrhage following operations for varicocele or hydrocele is best met by opening the wound. In cases of bleeding into the scrotum after operations for hernia the clot may be evacuated by incising the scrotum below the wound, packing the cavity with gauze and applying a snug spica. If this does not succeed, the operative wound must be opened.

Infections of the scrotum quickly spread because of the loose cancellous tissue and difficulties of natural drainage. The patient should lie on the back in the horizontal position; *i.e.*, with the pelvis not sunken into the bed. The scrotum should be elevated by a sling. In acute infections with edema, warm wet dressings are of value. Strong antiseptic solutions should not be used because of the sensitiveness of the scrotal skin. Boracic acid solution may be employed. *Erysipelas* is to be treated as in other parts. *Abscess* should be incised. *Gangrene* and *sloughing* of the scrotum, often following infections, should be treated by providing free drainage and by cutting away sloughing tissue. After such conditions the testicles may be left exposed with but little scrotal skin remaining; but such wounds heal readily by granulation and draw together the remaining skin so that the testicles become covered without plastic operation.

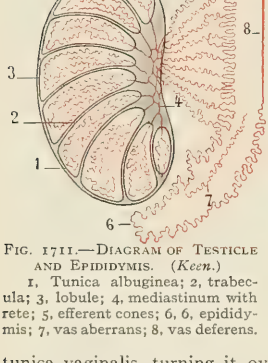


FIG. 1711.—DIAGRAM OF TESTICLE AND EPIDIDYMIS. (*Keen.*)

1, Tunica albuginea; 2, trabecula; 3, lobule; 4, mediastinum with rete; 5, efferent cones; 6, 6, epididymis; 7, vas aberrans; 8, vas deferens.

Edema of the scrotum, due to chronic vascular obstruction, may be relieved by excising a piece of deep fascia, incising the tunica vaginalis, turning it over the testicle, and closing the skin wound. This operation is not of service in old cases with sclerotic tissue.

Elephantiasis, due to the *Filaria sanguinis hominis* or other lymphatic obstruction, is treated by plastic operation. The skin and subcutaneous infiltrated tissue of the enlarged scrotum are cut away, leaving enough skin to close the wound under the testicles. The penis in these cases is usually found buried in the scrotum. Enough skin should be left about it to reconstruct its covering. The results in these operations have been very satisfactory.

Elongation of the scrotum, either with or without varicocele, is treated by excision of the bottom of the scrotum. In performing this operation, the testicles and the cord may be held up out of the bottom of the scrotum by the two hands of an assistant, while the redundant tissue below is cut off and the wound sutured (Fig. 1712). By applying two clamps transversely, hemostasis is secured while the incision is made. The clamps should be removed, each bleeding point ligated, and the wound sutured. The corners

should be rounded off. Varicocele may be operated upon through this wound at the bottom of the scrotum without making any separate incision.

Tumors of the scrotum do not require different treatment from that of tumors in other parts. Benign tumors are easily removed. Carcinoma should be widely excised. Melanotic sarcoma is rapidly fatal unless early removal of the growth has been secured.

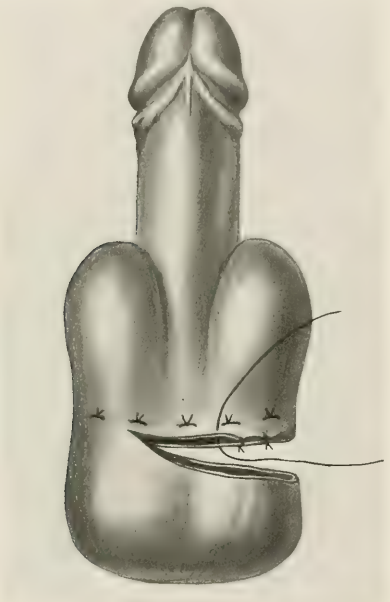


FIG. 1712.—RESECTION OF LOWER PART OF SCROTUM.
The testicles are pressed upward and the redundant scrotum is amputated after placing a row of sutures.

THE SPERMATIC CORD AND TESTICLES

Hemorrhage and **hematoma** should be treated as above described. Small collections of blood will be absorbed; large or infected hematomata should be incised and evacuated. This is applied to blood both within or external to the tunica vaginalis. In chronic **hematocele of the tunica vaginalis,** most common in men with arteriosclerosis, the most satisfactory treatment consists in removal of the entire sac by careful dissection.

Contusions of the testicles should be treated by rest and elevation of the scrotum in a suspensory bandage.

Wounds of the testicle require suture if the wound is large. The deep

fascia and the skin should be sewed separately. Smaller wounds and punctured wounds should be treated by shaving the skin and applying a copious wet dressing. The scrotum should be suspended and the patient kept recumbent.

Wounds of the spermatic cord require ligation of bleeding vessels. In **wounds of the vas deferens,** if there is division of the caliber of the tube, the divided tube should be sutured with the finest chromic catgut. It is entirely possible to restore the continuity of the tube even though some leakage takes place at first. The operation should always be attempted, as sterility may result if it is not done. In suturing the vas, by making the ends to be united oblique, the danger of scar contracture is minimized. It is sufficient, however, to pass a suture into the lumen of each end and through the wall of the tube, and tie it. Restoration of continuity has followed resection of as much as 1.25 cm. (½ inch) without suture.

Acute inflammations of the testicle (orchitis) and of the **epididymis** (epididymitis) require rest in the recumbent position with the testicles suspended.

Fig. 1713.—Suspension of Scrotum by Means of Adhesive Plaster Bridge.

Suspension of the testicles is best accomplished as follows: A belt of cotton cloth is pinned about the waist. A piece of gauze is folded several times until it is about 10 cm. (4 inches) wide. This is then placed under the scrotum, drawn up until the testicles lie on a level with the pubes, and the ends made fast to the belt at the waist. A pin, catching the two edges together, behind the scrotum, makes a sling for the testicles. If the patient has not the intelligence to keep this in place, two strips may be carried from it under the perineum and made fast to the belt at the sides.

Still higher suspension may be secured by placing a broad strip of adhesive plaster across the front of the thighs and laying the scrotum on this (Fig. 1713).

Suspension of the scrotum is the most important step in treatment. It usually gives much relief. If there is still discomfort, hot applications may be made; or if cold is more grateful, it may be used.

The slow healing of gonorrheal epididymitis under conservative treat-

ment has lead some surgeons to more radical measures. The skin is prepared as for a surgical operation. The skin is anesthetized with cocain in a line 2.5 cm. (1 inch) long opposite the epididymis. The swelling and chief infection is usually in the globus minor, and it should be the object of attack. The needle is passed into the globus minor at the bottom of the testicle and a few drops of cocain solution injected. The skin is incised along the anesthetized line, and as the globus minor is exposed several punctures are made into it with the point of the knife. A probe is inserted into each puncture and a channel opened parallel with the vas. The wound is packed with iodoform gauze and a dressing applied. Prompt healing follows whether pus is present or not.

Another method of performing this operation is as follows: Under light general anesthesia, an incision, 3 cm. (1¼ inches) long, is made over the swelling of the globus. This is carried down to the tunica vaginalis which is opened the full length of the skin incision, and the fluid drained off. Forceps then pick up each side of the wound in the tunica and the congested and swollen globus is exposed. An incision 1.3 cm. (½ inch) long is then made in the globus and a probe inserted and passed into the substance of the epididymis in several directions. A drain of rubber tissue or wicking is introduced into the substance of the gland, the skin wound partly closed and a dressing applied.

These operations cause prompt relief of pain and fever. The drain may be removed by the end of two days; and the parts will be found quite free from pain. The patient should be kept in bed for four or five days. If *suppurative orchitis* develops, it should be treated by incision.

Chronic orchitis follows the acute stage, and the suspension of the testicles is still necessary. The patient need not be kept in bed but may be about with a suspensory bandage. *Swelling* and *induration* of the testicle, persisting two or three weeks after the acute symptoms have subsided, are best treated by gentle pressure. This may be secured by an elastic bandage applied smoothly over gauze so as to make pressure upon the testicle to promote absorption of exudate. The same may be accomplished with adhesive plaster. The scrotum should be shaved before its application. The swollen testicle is then isolated in the scrotum and grasped; a strip of adhesive plaster 1.25 cm. (½ inch) wide is caused to encircle the scrotum above the testicle, thus confining it alone; similar strips are then applied vertically and horizontally around the imprisoned testicle. The swelling under this treatment steadily subsides, so that the dressing must be renewed every second day.

Orchitis which has resulted in fistulas and much scar tissue should be treated by injecting the fistulas with silver solution. This failing, curettage of the fistulous tracts should be practised. If the fistulas refuse to heal orchidectomy becomes necessary (see Fistula, Vol. I, page 304).

Tuberculosis of the epididymis and testicle usually first involves the epididymis and later extends to the testicle. The general principles of treatment are the same as for tuberculosis in other organs (see Tuberculosis, Vol. I, page 276). This rule may be adopted: In cases in which the whole of a tuberculous lesion or lesions is accessible and can be extirpated as a malignant growth, it should be operated upon and the tuberculosis excised; but if other foci which are not amenable to surgery are present in other parts of the body then operation is not advisable unless directed as a palliative measure for the relief of some local condition. Thus in tuberculosis of the testicle, if the most careful examination excludes tuberculosis in other organs, the tuberculous focus should be excised. If only the epididymis is involved,

it alone should be removed. If a definite part of the testicle also is invaded the diseased part should be excised, leaving the healthy tissue. If at the same time there are foci in other organs, all of which are removable, these foci also should be removed. The exceptions are the seminal vesicles and prostate.

This rule is difficult of application because of the difficulty of determining the existence of tuberculosis in other parts of the body. It is for this reason that in the presence of the difficulties of diagnosis and location of tuberculosis in its early stages, the general constitutional treatment of the disease has much to offer. When operation is done, the constitutional treatment should be carried out upon the assumption that other foci of tuberculosis exist, and which probably do exist. A decided disadvantage of operation is that constitutional treatment is not so easily and willingly submitted to if something already has been done in the nature of an operation as it is if nothing else has been undertaken and the patient feels that it alone is his only recourse.

If only the epididymis is involved, its removal is simple. The patient should come to the operation with 150 c.c. (5 ounces) of urine or water in his bladder. A vertical incision just above the testicle on the front of the scrotum exposes the organ. After the epididymis is dissected free from the testicle, the vas deferens is divided and its stump is brought out through a small wound higher up, and allowed to project through the skin. With a syringe fitted with a fine tip, 4 c.c. (1 dram) of phenol are injected into the vas. For this purpose, an ordinary hypodermic needle, the point of which has been ground off, is useful. The stump of the vas is fastened to the skin with a fine suture and covered with a pad of gauze soaked with alcohol. If this is done the skin wound may be sutured without drainage. This procedure is carried out because the vas may be infected, and because it drains the seminal vesicle and in most of these cases the contents of the vesicle is infected. By conducting this discharge to the surface, infection of the wound is prevented. After this operation the urethra should be washed out. The phenol which enters the bladder is diluted by the urine. Some pain follows the operation.

In most cases of tubercular epididymitis, the seminal vesicle and prostate are also involved. Radical surgical treatment of these organs need not be added to the epididymectomy. After removal of the epididymis, the prostatic and epididymal lesions may be expected to heal under hygienic treatment.

Syphilis usually affects first the testicle, and is amenable to constitutional treatment (see Syphilis, Vol. I, page 283).

Fungus of the testicle is that condition in which there is an opening in the overlying coverings of the testicle and the glandular substance of the organ protrudes. When due to chronic inflammation the inflammatory area should be excised. When due to accidental wound the skin and fascia should be dissected free from the testicle and sewed over it so as to close the opening in the scrotum.

Tumors of the testicle should be treated as tumors in other parts. *Benign tumors* should be excised, leaving as much of the testicle as possible. *Sarcoma* is rapidly fatal unless completely extirpated. *Carcinoma* usually proves fatal because operation is too long deferred. The reason for the high mortality in malignant tumors of the testicle is that a swollen testicle first suggests inflammation, and a differential diagnosis is made too late.

In carcinoma of the testicle the postperitoneal lymphatics should be dissected out if the patient is to be given the best chance of recovery. On

the right side the lymph nodes, connected with the testicle, lie on the connective tissue covering the vena cava, and on the left side on the aorta. There are four or five of these lymph nodes on either side, situated between the renal vessels and the bifurcation. Occasionally a node lies on the external iliac vessels (Fig. 1714). These lymphatics become involved early, and from them further metastases may long be delayed. Their early removal is imperative. When the enlargement of these lymph nodes can be discovered by palpation before operation, operation probably has nothing to offer. It is in the cases in which the glands are not perceptibly enlarged that hope of cure is best.

The operation should be performed in two stages. At the first operation the testicle is removed, and the diagnosis confirmed. At the second operation the patient should be placed in a position midway between the dorsal and lateral decubitus, with a pillow between the pelvis and ribs. A skin incision is made from the groin, at the upper end of the former inguinal incision, continued upward and outward parallel with Poupart's ligament, curving upward in the axillary line, in front of the anterior superior iliac spine, and then continuing upward in the axillary line to the ribs. The incision should be carried through fascia and muscle down to the peritoneum. The peritoneum is stripped back and the psoas muscle and kidney exposed. The ureter and mesenteric vessels should be lifted forward with the peritoneum.

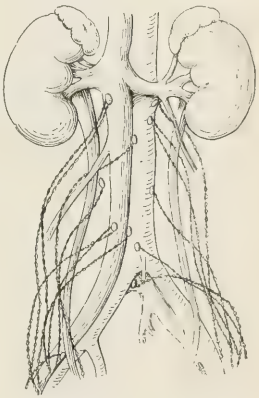


FIG. 1714.—ANATOMY OF LYMPHATICS WHICH SPRING FROM THE TESTICLES.

Beginning then in the groin with the stump of the cord, the spermatic vessels, lymphatics and connective tissue are dissected upward. The vas deferens is divided. Care should be taken not to injure the ureter or mesenteric vessels. The dissection should be carried upward, removing the structures especially at the bifurcation and along the great vessels, as far up as the renal vessels. The dissected tissue should be kept in one mass. Some surgeons prefer to begin the dissection above and work downward. After the dissection, the wound is closed with drainage. The peritoneum should not be opened. There should be but insignificant loss of blood and no serious depression.

Torsion of the cord has often been mistaken for incarcerated hernia. If seen within the first few hours the torsion should be relieved by untwisting the rotated cord. If as much as eighteen hours have elapsed this will be found difficult; and even if it can be accomplished, atrophy of the testicle is to be expected as a result of occlusion of the vessels. The testicle should be saved if possible. If gangrenous, it should be removed. **Rotation of the testicle** should be treated by untwisting it, if seen early enough. It should not be removed unless gangrene demands its removal. **Dislocation of the testicle** into the groin, perineum or other adjacent regions may be cured by pressing back the organ to its natural position. If it has become adherent in its dislocation it should be cut down upon, dissected free and sutured in its natural position. **Abnormal mobility of the testicle**, which is responsible

for the above-mentioned lesions, is cured by exposing the organ, removing the peritoneal pouch which commonly extends into the scrotum in these cases or by anchoring the testicle with a few sutures.

Undescended testicle, situated in the abdomen or in the inguinal canal demands operative treatment because of the danger of: (1) hernia which if not already present is apt to develop; (2) painful injuries and traumatic inflammation; (3) rotation of the testicle, causing strangulation of the cord; (4) atrophy of the testicle from pressure and defective circulation; (5) nervous irritability; and (6) mental depression. Without operation a cure can rarely be expected.

If the testicle is within the inguinal canal or just above it, operation should be done as early as the second or third year of age. There is no advantage in waiting as some have recommended till the child is eight or

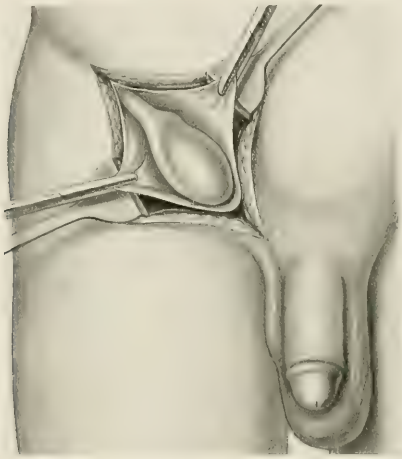


FIG. 1715.—OPERATION FOR UNDESCENDED TESTICLE.
The sac is incised and the testicle exposed.

fourteen years of age because the organ is degenerating during that time. Operation is not called for, except for hernia, if the testicle is in the scrotum part of the time but ascends into the abdomen when the surgeon examines it.

Many operations have been devised for this condition. None are easy. The experienced surgeon only should attempt any of them. The operation devised by A. D. Bevan is the most practical. An incision is made through the anterior wall of the inguinal canal exposing the pouch of peritoneum which extends toward the scrotum. The peritoneum should be divided, exposing the testicle with its tunica vaginalis (Fig. 1715). This vaginal process of peritoneum, which in children is of diaphanous thinness, should be divided transversely above the testicle. The upper opening which leads into the peritoneal cavity should be closed with a ligature. The peritoneal sac adjacent to the testicle should be stitched about with a fine continuous

suture, making a tunica vaginalis such as embraces the normal testicle (Fig. 1716). The peritoneum is then stripped back from the cord while the cord and testicle are drawn downward. The facility with which the testicle can be drawn down depends much upon the age of the patient. Firm bands or threads of tissue which offer resistance must be divided. Only the vas and its vessels need be spared. It will usually be found that the structures which offer the main resistance are the spermatic artery and veins. These should be cut between two ligatures. The vessels of the vas are adequate for the nourishment of the testicle. A pocket in the scrotum should then be made by blunt dissection, and the testicle placed in the bottom of this pocket. The wound should be closed as for inguinal hernia, leaving the cord in its natural position.

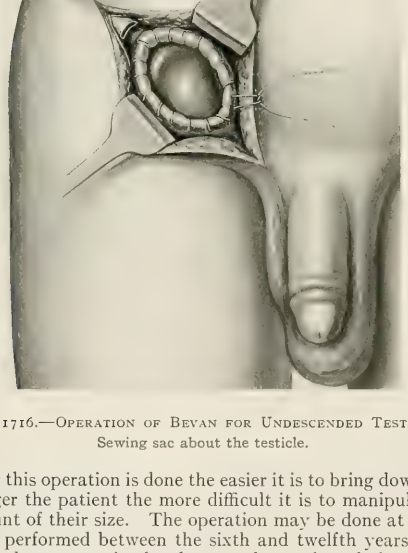


FIG. 1716.—OPERATION OF BEVAN FOR UNDESCENDED TESTICLE
Sewing sac about the testicle.

The earlier this operation is done the easier it is to bring down the testicle; but the younger the patient the more difficult it is to manipulate the structures on account of their size. The operation may be done at any time. It is most easily performed between the sixth and twelfth years. The longer it is deferred the greater is the danger of atrophy of the testicle. The simplest way to retain the testicle in the scrotum is to unite its tunica vaginalis to that of the other testicle.

Some surgeons have amplified the operation by making an incision through the bottom of the scrotum and another incision in the adjacent thigh. The testicle is sutured to the opening in the fascia of the thigh and the skin edges of the scrotal and thigh wound are united. Later the testicle is liberated and the scrotum cut free from the thigh.

Cases operated upon as late as puberty are often found to have a cord so short that none of the above operations is adequate. In such cases

the anterior wall of the inguinal canal should be laid open, and then the posterior wall, and the cord allowed to drop down upon the pubic bone. The canal is then closed as for hernia and the testicle fixed in a pocket in the scrotum.

As a preliminary to curative operation, the scrotum may be incised and a round foreign body temporarily placed in the bed which should be occupied by the testicle. For this purpose a large glass marble may be used in children or a small china egg in adults. Such an object worn in the scrotum five or ten weeks causes the scrotum to be drawn down and better adapted to contain a testicle. Between the two operations the patient should remain rather quiet.

The operation which preserves the sac and covers the testicle with it opens the inguinal canal as for hernia. The sac, testis, and vessels are dissected free from the surrounding structures. The gubernaculum will be found extending from the lower end of the testis to the bottom of the scrotum. It should be identified and isolated but not divided. A. D. Bevan divides it.

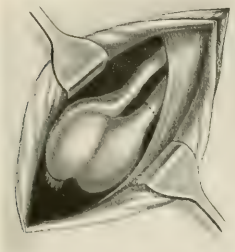


FIG. 1717.—OPERATION FOR UNDESCENDED TESTICLE.

The testicle, sac, and cord are isolated, and the sac divided at its neck.

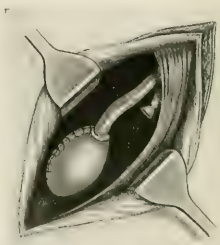


FIG. 1718.—OPERATION FOR UNDESCENDED TESTICLE.

The sac is divided longitudinally, wrapped about the testicle and sewed.

In adults a search should be made for a loop of the vas which may have descended into the scrotum. The vas and the spermatic vessels should be separated from the sac. If possible, the sac should not be opened. As the cord is held aside, the sac should be opened, if necessary. The contents should be dealt with as for hernia. The sac then should be divided transversely at a level sufficiently high above the testicle to give enough sac to cover the gland (Fig. 1717). The upper end of the sac should be ligated high as for hernia, after the vessels and vas have been separated high up from the peritoneum. This separation should be carefully done and so effectively that the testicle can be carried to the bottom of the scrotum.

The split-open lower end of the sac is then wrapped about the testicle and, thus inverted, is sewed over it as an envelope with fine catgut (Fig. 1718). The gubernaculum emerges at the lower end. The testicle is drawn down and the external inguinal ring closed with catgut suture. The canal is closed as for hernia. The testicle may be caught with a suture or two at the bottom of the scrotum if the gubernaculum has been divided. The wound is closed.

In the more simple cases in which no sac is to be considered a libera-

tion of the elements of the cord constitutes the feature of the operation. The incision is made as for inguinal hernia, the aponeurosis of the external oblique is split, and the inguinal canal opened. The cremasteric fibers are picked up and divided. The cord is then brought out as for hernia, the peritoneal projection is separated from it, and the testicle separated from all of its connections excepting the spermatic cord. The object of the operation is a lengthening of the vas and the vessels. The veins are separated from the cord and drawn aside. The vas and its vessels are next isolated. The remaining part of the cord is fascia, muscle and connective tissue, which are divided and stripped back. By carrying the separation of the vas and its vessels upward well toward the abdominal cavity, sufficient elongation will be secured to permit the testicle to be placed in the bottom of the scrotum.

Obstructive aspermia, deficiency of spermatic secretion, when due to obstructive lesion, is amenable to surgical treatment. The most common form of the disease is due to gonorrheal epididymitis, whereby the seminal tubule of the epididymis is occluded. The secretion of the testicle causes dilatation of the tubule above the obstruction. It is possible to incise the epididymis at the site of dilatation, divide the vas obliquely, sew the divided vas (both distal and proximal ends) into the incised epididymis, and reestablished the current of seminal fluid.

These cases are hopeful because the testicle, even though occlusion of the vas has existed for many years, continues to retain its power of producing spermatozoa.

Usually the obstruction which causes the *sterility* after gonorrhea is in the epididymis; but it may be in the vas or ejaculatory ducts. Before attempting an anastomosis, the location of the obstruction should be determined. After exposing the vas in the upper part of the scrotum, the patency of the canal may be tested by injecting a solution of methylene blue, indulin, or carmin. The operation may be done under local anesthesia, and need not interfere with the patient's occupation. The appearance of the coloring matter in the urethra testifies to the patency of the canal.

E. Martin (Trans. Am. Urolog. Assoc., 1909) who first did a successful operation, in some cases made a lateral anastomosis, and in other cases he cut off the vas, split the end and sewed the split end into the epididymis. Before making the anastomosis, the milky fluid which exudes from the incised epididymis should be examined for spermatozoa. If none are found, incision should be made nearer to the testicle or in the head of the testicle itself.

H. H. Morton makes an incision in the scrotum and brings out the testicle. The vas is then isolated for a short distance, divided and the end split open. The epididymis is incised, the fluid examined, and the split end of the vas sewed in the wound in the epididymis with three sutures.

In cases in which there is obstruction in the vas the site of the obstruction may be located by exposing the vas and injecting it with fluid. If the obstruction is near enough to the testicle the testicle may be lifted up and anastomosis made beyond it. If the obstruction is beyond the reach of the testicle, the strictured segment may be resected, and the divided epididymis united by end-to-end anastomosis.

If the obstruction is in the ejaculatory duct, the seminal vesicle must be exposed, opened, and a new opening made into the urethra, which should be kept patent with a small bougie while it is becoming lined with epithelium.

In cases in which no canal can be restored a reservoir for the receipt and storage of spermatozoa may be constructed in the scrotum. The testicle should be exposed, the tunica vaginalis incised as far from the epididymis as

possible. The head of the epididymis is then shaved off and the wound closed. As a result of this operation it may be hoped that spermatozoa will discharge into the tunica vaginalis sac; when wanted for artificial impregnation this spermatic fluid may be aspirated.

Anastomosis of the vas deferens to the epididymis of the opposite side, for sterility was done by F. R. Hagner (Surg., Gyn. and Obst., xix, 1914). The vas was divided and carried through the septum of the scrotum to the opposite epididymis.

Hydrocele (an accumulation of serum in the sac of the tunica vaginalis) requires operation for its cure. But besides operation the surgeon should apply hygienic treatment, for this disease is often due to tuberculosis and rarely occurs in healthy men. Operation should not be applied to the cases

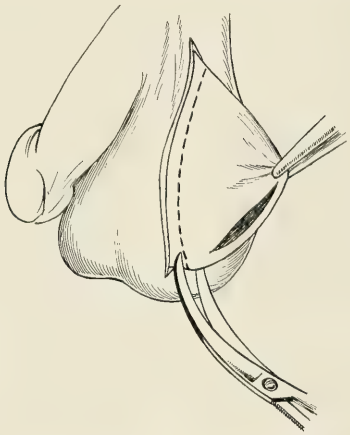


FIG. 1719.—OPERATION FOR HYDROCELE.
The sac is incised, emptied of fluid, drawn out, and cut away external to the testicle.

associated with acute infections of the epididymis, as the effusion in these cases usually will subside with the subsidence of the infection.

Many operations have been devised. None is without disadvantage, because in order to cure the disease the sac cavity is obliterated and replaced by connective tissue, while the healthful functioning of the testicle requires that it be partly embraced by a lubricated sac.

The *operation* which I have practised for twenty years with the greatest satisfaction has been as follows: The scrotum and surrounding region being shaved and cleansed, cocain local anesthesia is applied, and an incision the length of the sac is made on the anterior aspect of the tumor. Before making this incision the location of the testicle should be determined so that the surgeon may be satisfied that it is not in danger of being wounded. This seems to be a long incision but when the fluid has escaped it will be found surprisingly small. The hydrocele sac is exposed, and incised the full length of the sac, above to its summit and below as far as the testicle. The fluid gushes forth, and the edges of the sac are caught with forceps. The sac

readily is drawn forward out of the wound, and its anterior half is cut away (Fig. 1719). The edge of the skin is then sewed to the edge of the sac by a running suture of fine catgut (Fig. 1720). The inside of the remaining portion of the sac including the serous-covered surface of the testicle, is dried and painted with tincture of iodin. The sac cavity should then be nearly filled with sterile vaselin and gauze wicking packed upon that. The object of the ointment is to prevent the gauze adhering to the sac and to render its removal at the first dressing painless. The gauze serves to keep open the mouth of the wound. Instead of using ointment, the cavity may be lined with rubber tissue and the gauze packed upon it.

The dressing should be changed every second day. The mouth of the wound tends to contract faster than the depth of the sac. If the mouth falls together and becomes adherent reaccumulation and retention of fluid

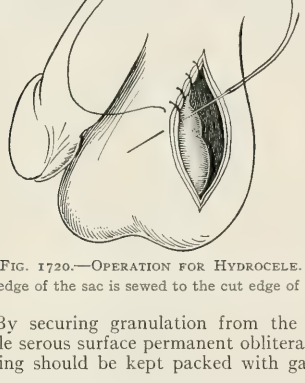


FIG. 1720.—OPERATION FOR HYDROCELE.
The cut edge of the sac is sewed to the cut edge of the skin.

may take place. By securing granulation from the bottom of the sac throughout the whole serous surface permanent obliteration of the cavity is secured. The opening should be kept packed with gauze so long as any cavity remains.

When operating under local anesthesia it will be found that the sac is sensitive and that sensation becomes more acute as the testicle is approached. This sensitiveness can be overcome only by infiltration anesthesia, by injecting the nerve trunks as they emerge from the inguinal canal, or by general anesthesia. In a healthy young man the operation is much simplified by general anesthesia.

Instead of cutting away part of the sac, it suffices to open it and sew the edge to the skin edge. The only disadvantage of this procedure is that a larger and deeper cavity has to be dealt with, and a longer period is required for healing, during which the mouth of the sac must be prevented from closing and leaving a cavity included behind it.

Instead of cutting away part of the sac, the whole sac may be cut away as far as the testicle. When this is done the serous covering of the testicle is treated with tincture of iodin, and the wound closed with drainage which may be dispensed with entirely after the first or second dressing.

Treatment by *eversion of the sac* is preferred by many surgeons. It is a very satisfactory operation in recent hydrocele, but is not applicable to cases of

long standing or cases in which the injection treatment or inflammation has caused a thickening of the sac wall. Jaboulay incised the sac, everted it, and sewed its edges, leaving its inside out (Fig. 1721).

The operation devised by E. W. Andrews is still more simple as it requires no suture. An incision is made through the skin on the anterior surface of the scrotum. This incision should be about three-fourths the length of the hydrocele. All of the structures down to the sac should be divided. The sac should then be freed by blunt dissection throughout its entire surface. This dissection should isolate the sac as a thin translucent bag, containing the testicle and spermatic cord in its wall, and bring it outside of the scrotum. The sac is then incised at its extreme upper limit. An opening about 2.5 cm. (1 inch) in length should be made, terminating above at the cord (Fig. 1722).

Through this opening, as the fluid escapes, the testicle is pressed out of the sac. As the testicle escapes, it brings with it the sac. In this manner the sac is everted until its serous coat and the testicle are wholly outside of the sac wall (Fig. 1723). No sutures in the sac are required. It is dropped back

FIG. 1721.—OPERATION FOR HYDROCELE BY EVERSION OF THE SAC AND SUTURE.

The sac is incised, and the redundancy cut away. It is turned inside out, and sewed. If the sac is not large none of it need be removed. Diagram showing endothelial lining of sac.

into the scrotum and the skin wound closed. This operation is strongly recommended by Andrews.

After any cutting operation for hydrocele it is best that the patient should remain in bed for a few days.

The operation of *tapping* for hydrocele is to be recommended in some cases. *In young children* a cure is usually affected simply by drawing off the fluid with a fine needle. *In adults* simple withdrawal of the fluid may be practised as a tentative measure; it offers little hope of cure.

Tapping followed by the *injection* of irritating fluid to set up adhesive inflammation is a much employed operation. It is simple and offers a cure in the majority of cases. In some cases a second or third treatment becomes necessary. R. H. Herbst has made the important contribution to the technic of injection in discovering that success can be guaranteed by washing out the serum from the sac, the albumin of which neutralizes the injected drug.

The operator should locate the testicle and grasp it with the tips of the fingers of the left hand. With aseptic care, in an anesthetized spot, a small trocar and canula are inserted through the skin and wall of the sac into the fluid. There is no excuse for wounding the testicle or cord. The fluid should be permitted to run out until the sac is as nearly empty as it can be made. Then the sac is washed out with sterile water until no serum remains.

To be on the safe side the surgeon should continue washing until the return flow is negative to the nitric acid test for albumin. Then 10 c.c. (150 minims) of a 95 per cent. solution of phenol are injected through the canula into the

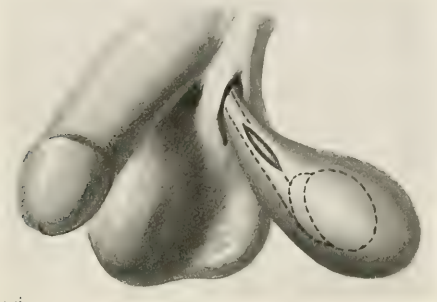


FIG. 1722.—OPERATION FOR HYDROCELE BY EVERSION OF THE SAC WITHOUT SUTURE. The sac has been exposed by a short incision, incised at its extreme upper limit, emptied of fluid, and extruded from the scrotum.

sac. This fluid is allowed to remain in the sac for half a minute. It is then allowed to flow out, and 10 or 15 c.c. (150 or 225 minims) of alcohol are injected. The excess of alcohol is allowed to run out after half a minute.

FIG. 1723.—OPERATION FOR HYDROCELE BY EVERSION OF THE SAC WITHOUT SUTURE. The sac having been incised at its extreme upper limit, the wound is enlarged just enough to permit passing the testicle and sac through the opening in the sac. After the inversion, the wound is seen grasping the cord which emerges through it. In this inverted condition, the testicle with its enveloping sac, is returned to the scrotum.

The canula is then withdrawn, the place of puncture is compressed between the fingers and a piece of gauze applied. Slight burning pain is present for a short time. The operation is followed by swelling up to about half the size

of the tumor before the operation. This fluid is usually absorbed in from four to six weeks.

Tincture of iodin has been used for injection purposes. Also 2 or 3 c.c. (30 or 45 minims) of a one-third dilution of liquor formaldehyd has been successfully employed. These injections are followed by considerable pain, and are not as satisfactory as phenol and alcohol.

After the operation by injection the patient should be kept quiet for a few days. The operation is not applicable to old cases with thick-walled sacs.

In *hydrocele of the cord*, a cure is usually affected by withdrawal of the fluid and the injection of 5 or 10 drops of phenol. In the cases with thick-walled sacs excision of the sac or free opening and gauze packing is called for. *Hydrocele of the round ligament* in the female is cured by evacuation and injection. In hydrocele of the cord which communicates with the general peritoneal cavity and in hydrocele of a hernial sac, the treatment should be by open operation, excision of the sac, and closure of the wound as for hernia. Hydrocele in which the sac passes into the abdomen but is closed off from the general peritoneal cavity, if not complicated by hernia, may be cured by incision at the lower pole, the insertion of a drainage tube, and daily irrigation of the interior of the sac with some mildly irritating antiseptic solution, such as tincture of iodin, silver nitrate, or emulsion of iodoform. Hydrocele of the cord or inguinal canal should not be tapped, because of the possibility of a complicating hernia; such hydroceles should be exposed to sight by operative incision.

There are other methods of treating hydrocele. *Extirpation of the unopened sac* is practised by some surgeons. The operation is not difficult in cases of thin-walled sacs. By beginning above, the sac may be separated from the cord and then from the testicle by blunt and cutting dissection. Some vessels require to be tied. The operation is well thought of by Willard Bartlett. The *catgut treatment*, recommended by C. M. Whitney, consists in introducing a good-sized trocar and canula, drawing off the fluid, and then introducing into the sac through the canula 25 cm. (10 inches) of No. 2 catgut. The catgut is pushed through the canula with a probe, the puncture is sealed with a drop of collodion, a suspensory is applied, and the patient allowed about after the first day. The scrotum swells to about half the size it was before the operation. In from four to six weeks, the swelling has disappeared. The effect is similar to that following phenol injection except there is no pain.

Spermatocele, connected with the testicle or epididymis, should be treated by excision of the sac, and closure of the wound.

Varicocele, usually limited to the left side, and involving the spermatic veins, is a common and easily cured condition. In the majority of cases the disease gives rise to no symptoms and requires no treatment. When dragging pain in the groin, pain in the testicle, aching pain in the back, mental distress, or other symptoms are present, treatment is called for. Most cases require no operation; improvement of the general health, improved sexual hygiene, and improving the local tone by cold baths are all that are necessary. It is doubtful if the wearing of a suspensory has any curative value, while it is quite possible that its use may aggravate the disease by reducing the tonicity of the spermatic musculature. The dragging sensation may be relieved by the use of a suspensory, but the disease is not apt to be cured by it while the parts are weakened and the necessity for its continued use is increased. Moreover, a suspensory is at no time an agreeable article of wearing apparel, and in warm weather it becomes a positive nuisance. If there is much elongation

of the scrotum, the symptoms of which are relieved by a suspensory, it is better to cure it by shortening the scrotum (see page 302).

When *operation* for varicocele is required, because other measures fail or because the patient demands operation, excision of the varicose veins of the spermatic cord is commonly done. The preparation of the region should be the same as for hernia. General anesthesia may be used, but in experienced hands the operation can be done perfectly well under local anesthesia. An incision 2.5 cm. (1 inch) long begins at the middle of the external inguinal ring and passes downward and inward in the direction of the cord. The skin is divided and with it the dartos. The thin intercolumnar fascia, the spread-out cremaster muscle and the membranous layer of infundibuliform fascia are separated by blunt dissection. These fasciæ should not be destroyed but should be dissected free from the veins. They should always be divided parallel with the long axis of the cord. The varicose veins are come upon

FIG. 1724.—OPERATION FOR VARICOCELE.
The veins have been isolated and tied. The vas deferens and its vessels are intact.

and lifted out of the wound. In aggravated cases the whole cord should be drawn out of the wound. The vas should always be identified by feeling. It lies posterior to the dilated veins.

A ligature of catgut should be tied around the veins near the testicle, but never so near as to embrace the epididymis. A second ligature should be tied about the same veins at the external inguinal opening (Fig. 1724). The spermatic artery should be identified and not included in the ligature. This is not a matter of great importance as the artery of the vas is capable of supplying the necessary nourishment to the testicle. The posterior group of veins, usually not enlarged, should be spared, or such of them as are not diseased. In any case at least one vein should be left in the posterior group to return the blood from the testicle. It is well to separate by blunt dissection the spermatic veins on one side and the vas and its vessels on the other. About 5 cm. (2 inches) of the spermatic veins are included between the two

ligatures. The intervening veins are excised, leaving the stump long enough to hold the ligatures. The ligatures should have been left long; and, after excision of the veins, the two stumps should be tied together, thus shortening the cord and lifting up the testicle (Fig. 1725). The wound should be closed by a subcutaneous suture, a snug dressing applied and the patient kept recumbent until the initial swelling has subsided.

Tying together the two stumps leaves a lump which requires several weeks for its absorption. This may be made less noticeable by sewing together the two stumps. In neurotic men the latter should be done.

When local anesthesia is employed, novocain in very dilute solution is used. The skin is first anesthetized. After the skin and superficial fascia have been incised, the deeper fascia surrounding the cord are infiltrated with

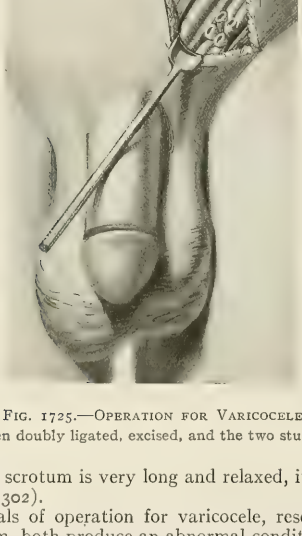


FIG. 1725.—OPERATION FOR VARICOCELE.
The veins have been doubly ligated, excised, and the two stumps tied together.

the solution. If the scrotum is very long and relaxed, its lower part should be amputated (page 302).

The two principals of operation for varicocele, resection of veins and shortening of scrotum, both produce an abnormal condition. The first may cause congestion of the testicle; the second does not cure the disease. It is best for the health of the testicle that the spermatic artery be left. If it is left, enough venous channel must remain to carry the return blood. The ordinary operation of resection of veins often fails to secure just the necessary physiologic balance of circulation, and pain and nutritive disturbances follow,

To meet these objections, D. Del Valle (Surg. Gyn., and Obst., xxii, June. 1916) devised a physiologic operation. An incision 5 or 6 cm. (2 or 2⅓ inches) long is made over the external ring. The infundibuliform fascia is incised and the mass of veins drawn out. The vas, the spermatic artery and a few accompanying veins are separated into an anterior group from the

diseased veins, which constitute the posterior group. The diseased veins are next separated into two groups, an anterior and posterior. A catgut ligature is tied around the posterior group one finger's breadth above the testicle. Another ligature of chromic catgut is tied around the anterior group two finger's breadth above the first ligature, and the ends left long. These measurements are important, and may be depended upon to shorten the cord 4 or 5 cm. (1½ or 2 inches).

An incision, 4 cm. (1½ inches) long, is then made through the fascia one finger's breadth internal to the external ring. Forceps are passed through this opening and caused to appear at the ring. The ends of the last ligature are picked up and the anterior group of veins drawn through the wound in

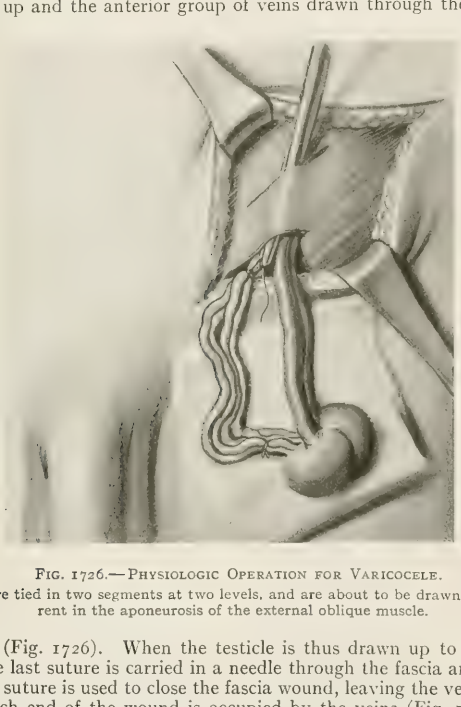


FIG. 1726.—PHYSIOLOGIC OPERATION FOR VARICOCELE.
The veins are tied in two segments at two levels, and are about to be drawn up through a rent in the aponeurosis of the external oblique muscle.

the fascia (Fig. 1726). When the testicle is thus drawn up to the desired height, the last suture is carried in a needle through the fascia and tied; the rest of the suture is used to close the fascia wound, leaving the veins anterior to it. Each end of the wound is occupied by the veins (Fig. 1727). The testicle is returned to the scrotum and the wound closed. This operation preserves the circulation, but relieves the vessels of the abnormal hydraulic pressure of the blood column.

Castration is done for destructive traumatism, destruction of the most of the organ by abscesses and sinuses which cannot be healed, gangrene, tuberculosis and tumor. The operation may be done under local anesthetic. When general anesthesia is employed, nitrous oxid is well adapted because the operation is quickly done. An incision is begun just below the external

inguinal opening and is carried downward on the scrotum as far as the middle of the testicle. This incision should pass through the skin and the several layers of fascia down to the cord and the tunica vaginalis. The testicle with the tunica vaginalis and the cord should be isolated by blunt dissection. The isolation of the cord should be carried as high as is necessary. In the case of malignant disease the fascial coverings of the cord should be removed with the cord, and the amputation should be made as high as possible. In ligating the cord, it is best to separate it into several smaller fasciculi and ligate each separately rather than throw a single large ligature around the whole mass. The wound in the scrotum may be closed by a subcuticular suture and a compressing dressing applied.

Partial vasectomy (removal of a section of the vas deferens) is done to produce sterility. When done for this purpose the operation must be carried

FIG. 1727.—PHYSIOLOGIC OPERATION FOR VARICOCELE.
The external oblique is seen sewed under the ligated veins.

out on both sides. It may be done under local anesthesia, first anesthetizing the skin and then, after incising the skin, infiltrating the cord with weak cocain solution, care being taken not to puncture a vein. The skin incision begins just below the external inguinal opening and extends downward in the line of the cord for 1½ inches (4 cm.). The coverings of the cord are divided and pressed aside. The vas is isolated and two ligatures are tied about it, 2 cm. (¾ inch) apart. A segment of the vas, 1.25 cm. (½ inch) in length, is cut out from between the ligatures. The two stumps should not be tied together. The upper stump should be doubled back upon itself and the ligature tied around the doubled tube. This causes angulation which more securely closes the tube against the entrance of spermatozoa. The skin wound may be closed with a subcuticular suture.

Testicle grafting has been done with varying success. Persons who have lost both testicles, and in whom a testicle from another person has been grafted, enjoy for at least a period the benefits of restoration of internal testicular secretion. This is probably not permanent. Where two testicles have degenerated two should be transplanted.

If some relic of testicle still remains, the grafting of testicle from another person may be expected to stimulate an hypertrophy and hyperplasia of the preëxisting tissue. This makes the operation well worth while.

The testicle to be implanted should be taken from the dead body of a young man or boy who has died without infective disease. Glands taken from the living are most desirable, but they can rarely be obtained. The whole gland with the epididymis should be implanted in the patient's scrotum in the position naturally occupied by the testicle. The remains of the patient's atrophied testicle should not be removed. If some time between the securing of the testicle and its implantation must intervene, it should be kept in normal salt solution in cool storage (see Grafting of Organs, page 648).

The grafted testicle should be inserted through a small wound in the scrotum and the wound closed without drainage.

It is possible that this treatment may be useful in senile dementia and other conditions associated with testicular atrophy. In testicular atrophy due to disease, injury, or cryptorchidism, this treatment is indicated, if the patient is suffering from lack of testicular secretion. Dementia precox, may possibly be benefited.

The implanted gland furnishes the hormone necessary for the full physiologic expression of the organism. Even after the implanted gland has atrophied to one-third or one-fourth of its normal bulk it apparently continues to supply internal secretion.

Impotence in the male requires local and general treatment. Most important is the cure of local disease. Deformities, stricture, urethritis, prostatitis, elongated prepuce, balanitis, and other diseases of the genito-urinary apparatus should be eliminated.

Local applications of electricity are useful. The faradic current is applied with the positive pole to the lower part of the spine, and the negative pole to the penis and testicles. Sponge electrodes are used. Or the negative electrode may be applied to the genitals and the positive to the inner surface of the thighs. A brush electrode may be passed up and down over the lower part of the spine. The galvanic current may be used on alternate days. Electricity may be applied to the prostate and deep urethra by means of an insulated sound.

Sinapisms of mustard, to excite congestion of the skin of the penis, are useful in some cases. Hot applications to the penis and scrotum just before copulation are efficacious.

The general treatment requires the correction of vicious psychic conditions and involves the art of the internist rather than the surgeon. The confidence of the patient must be restored. Men who have not contracted syphilis or gonorrhea and who have lived in normal marriage relations with one wife need not expect impotence, except that which must come to all as an expression of old age. Excessive sexual intercourse must be paid for by premature impotence. In men who are not old, sexual potence may be restored by a year of absolute abstinence from sexual intercourse or sex excitement. The general health should be improved. In these patients a diet rich in nitrogenous foods is desirable. Ferruginous foods, such as spinach, are useful for the anemic. The drugs used are cantharides, ergot, phos-

phorus and strychnin. Impotence, due to sexual hyperesthesia, requires sedatives such as chloral, bromids, hyoscyamus and opium. Tablets made of the anterior lobe of the pituitary body are said to be effective. The dose is 0.15 to 0.3 Gm. (2½ to 5 grains) thrice daily.

Sterility in the male requires the treatment of the cause. If due to impotence, the impotence should be cured. Obstruction in the vas deferens and the ejaculatory ducts should be relieved (see above). When an operation to cause sterility has been done by resection of the vas deferens, the patency of the seminal tube may be restored by exposing the two ends, removing the intervening scar tissue, and uniting the ends (see Operations on the Vas Deferens, page 311).

THE FEMALE GENERATIVE ORGANS

Anatomy.—The *labia majora*, the analogues of the scrotum, are external lips of the vulva or *external generative organs*. They extend downward on either side of the vulvar orifice from the *mons veneris*, or pubic eminence, to the perineum. Externally they are covered with hairy skin; internally the labia are covered with mucous membrane. A fold, called the *posterior commissure*, connects the two labia posteriorly. The commissure is about 2.5 cm. (1 inch) from the anterior margin of the anus. Above the commissure, at the lower part of the hymen, is a transverse fold called the *fourchette*. The ends of the round ligament blend with the tissues of the labia majora.

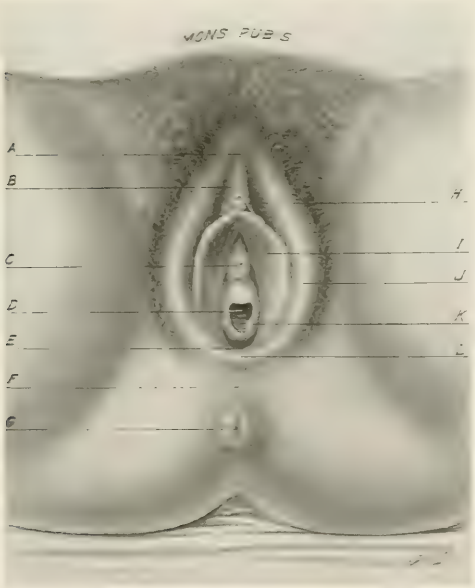


FIG. 1725.—EXTERNAL GENITAL ORGANS OF THE FEMALE.

A, Anterior commissure of labia; *B*, prepuce of clitoris; *C*, external urethral orifice; *D*, vaginal orifice; *E*, fossa navicularis; *F*, perineum; *G*, anus; *H*, clitoris; *I*, labium minus; *J*, labium majus; *K*, hymen; *L*, posterior commissure of labia.

The *labia minora*, or *nymphæ*, are two smaller lips lying just internal to the larger lips. They are covered with mucous membrane, and embrace the clitoris at their upper extremities. Below and externally they are continuous with the labia majora (fig. 1725).

The *clitoris* the analogue of the penis, lies just below the pubic arch. It is made up of two corpora cavernosa and a glans, and, with the exception of the urethra, it is similar to the penis. In the erect state it is about 2 cm. (¾ inch) long.

The *external urinary meatus* is below and posterior to the tip of the clitoris, by an interval of about 2.5 cm. (1 inch). It is situated just at the upper margin of the entrance to the vagina. The *corpus cavernosum urethræ* corresponds to the corpus spongiosum of the penis, connects the urethra and the clitoris, and sends *vestibular bulbs* downward on either side of the entrance to the vagina.

The *hymen* usually has the form of a thin semilunar fold of mucous membrane stretched across the lower part of the entrance to the vagina. In some cases it surrounds the orifice of the vagina and is perforated by an opening in its middle. Rarely it is imperforate.

The *glands of Bartholin* are usually two in number, one on each side of the vaginal orifice, about 1 cm. (⅓ inch) in diameter, partly behind the bulb of the vestibule and sphincter vaginæ muscle, and lying posteriorly upon the triangular ligament. Each gland empties by a long duct upon the inner side of the nympha external to the hymen.

The *bladder*, when slightly distended, lies just behind the pubes. Behind is the uterus, some folds of small intestine dropping between. Its base rests upon the neck of the uterus and the upper part of the anterior wall of the vagina. The average capacity is about 500 c.c. (1 pint). The upper surface is covered with peritoneum. In the erect position the opening (*internal urinary meatus*) is at the lowest part of the bladder. This is usually

FIG. 1729.—MESIAL SECTION OF FEMALE PELVIS.

A, Ovary; *B*, uterus; *C*, cervix uteri; *D*, rectum; *E*, vagina; *F*, anus; *G*, intestines; *H*, bladder; *I*, symphysis; *J*, urethra.

about 2.5 cm. (1 inch) behind the middle of the pubic symphysis. The bladder is supported by reflections of the pelvic fascia (see Bladder, page 182).

The *female urethra* is about 4 cm. (1½ inches) in length, and passes from the bladder downward and forward in contact with the upper wall of the vagina. It is a muscular tube, lined with mucous membrane lying in longitudinal folds. Numerous lacunæ and glandular openings mark the lower end of its interior. Just above the external meatus two small glandular ducts open through the mucous membrane on the posterior surface; these are the para-urethral ducts of Malpighi, more recently named the ducts of Skene. The urethra is capable of much greater dilatation than in the male.

The *vagina* is the canal which extends downward and forward from the uterus to the vulva. It receives the penis during copulation, and serves as a birth-canal during parturition. The length of its anterior wall is about 10 cm. (4 inches) and its posterior wall about 14 cm. (5½ inches). The anterior and posterior walls ordinarily lie in contact with one another. Anterior to it is the base of the bladder and the urethra. The lower three-fourths of the posterior wall is closely connected with the rectum; the upper fourth is separated from the rectum by the recto-uterine pouch (*cul-de-sac*) of peritoneum. The wall of the vagina consists of mucous membrane, muscle, and a surrounding layer of erectile tissue. The mucous membrane is covered with squamous epithelium, and is separated from

the muscular layer by loose areolar tissue so vascular as to have the character of an erectile structure. The muscular coat consists of an internal longitudinal layer and an external circular layer (Fig. 1729).

That part of the vagina which is at the extreme upper end and surrounds the cervix uteri is called the *fornix*. The fornices are spoken of as anterior, posterior and lateral.

The *uterus* is a pear-shaped muscular organ, situated in the middle of the pelvis, flattened from before backward, and capable of the enormous distention incident to pregnancy. Its fundus is directed upward and forward, and is free in the peritoneal cavity. Its lower end, the cervix, is directed downward and backward and is embraced by the upper end of the vagina In the nulliparous woman it is about 7.75 cm. (3 inches) long and 5 cm. (2

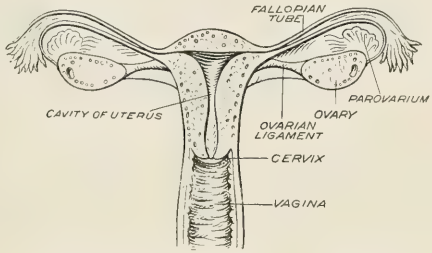


FIG. 1730.—TRANSVERSE LONGITUDINAL SECTION OF UTERUS AND ITS ADNEXA.

inches) wide at its upper part. Its wall is about 1.25 cm. (½ inch) thick. The cavity of the uterus is triangular in shape (Fig. 1730).

The upper three-fourths of the anterior surface is covered by peritoneum and is separated from the latter by coils of intestine. The lower fourth lies against the bladder. The posterior surface is covered by peritoneum as far down as the vagina. The lateral margin ends above in the *cornu*, at which is attached the Fallopian tube and below it the round ligament. These as they pass outward are embraced within the folds of the broad ligament. That part of the cervix of the uterus which lies below the attachment of the vagina is called the *portio vaginalis*.

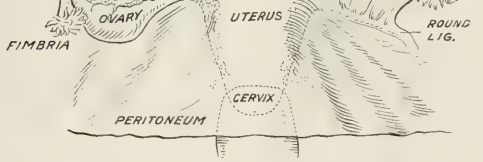


FIG. 1731.—DIAGRAM OF THE BROAD LIGAMENT.

The *round ligament* is a flattened cord which begins at the cornu of the uterus in front of the Fallopian tube and passes out through the inguinal canal to end in the tissues of the labium majus and the mons veneris. Each ligament is 10 or 12 cm. (4 or 5 inches) long. The other ligaments of the uterus are folds of peritoneum with the structures which they immediately embrace. The *vesico-uterine ligaments* are two curved folds passing anteriorly. The lateral or *broad ligaments* are the folds which pass to the sides of the pelvis in the form of an upright septum. The *recto-uterine ligaments* (*uterosacral*) are two in number, each passing from the posterior lateral wall of the cervix to the side of the rectum, and thence to the wall of the sacrum, embracing between them a pouch (the *rectovaginal cul-de-sac*) which represents the lowest limit of the peritoneum.

The cavity of the body of the uterus is triangular, flattened from before backward. The cervical canal is marked by a constriction above and below; between which is an ampulla. These constrictions are called the *os internum* and the *os externum*. At each *cornu* the Fallopian tube communicates with the uterine cavity by a small opening about 0.75 mm. ($\frac{1}{32}$ inch) in diameter.

The great bulk of the uterus is made up of unstriped muscle fibers. The lining of the uterus consists of columnar ciliated epithelium, interspersed with tubular glands. At the *os externum* the columnar epithelium ceases and becomes continuous with squamous stratified epithelium which covers the vaginal portion.

The *Fallopian tubes*, or *oviducts*, pass outward from the horns of the uterus, one on either side, and are embraced in the upper margin of the broad ligament. Each tube is about 10 cm. (4 inches) long. Its caliber at its inner end is so small that it will scarcely admit a fine bristle. At its outer extremity it widens and becomes trumpet-like, terminating in a fringed or fimbriated extremity, where the lining of the tube becomes continuous with the peritoneum and where its caliber opens into the peritoneal cavity. Thus the peritoneum in the female is continuous, through the genital tract, with the skin of the outside of the body.

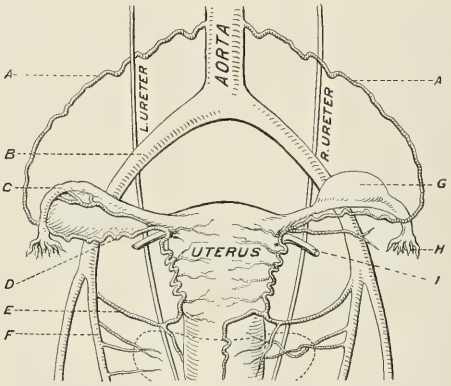


FIG. 1732.—ARTERIES OF THE UTERUS.

A, Ovarian artery; *B*, common iliac artery; *C*, Fallopian tube; *D*, ovarian branch of uetrine artery; *E*, uterine artery; *F*, internal iliac artery; *G*, ovary; H, fimbria of tube; *I*, round ligament (cut off). Dotted line indicates bladder.

The *ovaries* are analogous to the testicles of the male. They lie behind the broad ligament, behind and below the tubes. Each is an oval-shaped body in length from 2.5 to 5 cm. (1 to 2 inches). It is embraced by a fold of peritoneum of the posterior layer of the broad ligament which covers most of its surface and is reflected as a *mesovarium*. The tubes and ovaries are called the *uterine appendages*.

The *broad ligament* embraces between its two folds of peritoneum the following structures: The Fallopian tube; the round ligament; the ovary; the utero-ovarian ligament; the uterine and ovarian vessels; lymphatics; and uterine plexus of nerves (Fig. 1731).

The *ureters* lie in the base of the broad ligament 1.25 cm. ($1\frac{1}{2}$ inch) from the cervix. They then pass in the angle between the vagina and bladder and enter the bladder about opposite the middle of the anterior wall of the vagina. They are crossed upon their inner aspect by the uterine arteries.

The *vessels* of the uterus and appendages are of much surgical importance. The uterus is supplied by the uterine artery from the internal iliac, and by the ovarian artery from the aorta. The veins are of large size. All of these vessels approach the uterus between the folds of the broad ligament. The cervix receives vessels also from the vagina (Fig. 1732).

Instruments.—The special instruments required for female pelvic work are vaginal specula and retractors, volsella forceps, uterine dilators, uterine curettes, long forceps, pedicle clamps and ligature carriers.

THE VULVA

Wounds.—Wounds of the vulva are chiefly those due to parturition, the treatment of which is discussed under Lacerations of the Perineum. Incised, punctured and lacerated wounds from other causes should be treated the same as such wounds in other tissues. The hair should be shaved, the skin cleansed, bleeding checked, foreign matter removed and the wound sutured if it is larger than 1.25 cm. (½ inch) in length or if it causes a distortion of contour. A snug dressing should be applied.

Hemorrhage, from lacerations of the hymen and adjacent mucous membrane caused by brutal entrance of the vagina, is usually controlled by pressure with an antiseptic dressing. In some cases a spurting vessel requires to be ligated; and in aggravated cases the lacerated vulva and vaginal wall require to be sutured. In **hematoma of the vulva** if absorption does not take place in a week the tumor should be incised and the blood evacuated. Gauze packing should be renewed daily.

Inflammations.—*Simple vulvitis* should be treated by removing the cause and then maintaining cleanliness. In acute vulvitis the patient should be kept in bed. The preliminary cleansing may be secured by a sitz-bath or by irrigation. By placing the patient on a douche pan and irrigating the parts with warm boric acid solution, cleansing can be secured. Following the irrigation a copious dressing of gauze, soaked with boric acid solution should be applied. Other mild antiseptic solutions are also effective.

After the subsidence of the acute symptoms, if some discharge and irritability remain, a mild antiseptic astringent powder is of service. Bismuth subgallate with equal parts of stearate of zinc, zinc oxid and boric acid, or zinc stearate with 10 per cent. of powdered alum are useful. In connection with the use of powders, cleansing irrigations should be employed. After the irrigation the parts should be dried and the powder applied. Some cases do better with ointments. Simple vulvitis which does not respond to these measures should be treated with silver nitrate solution applied as for gonorrhea (see also Vaginitis, page 355).

In *follicular vulvitis* the follicles should be incised, the cavities dried out and swabbed with silver solution. Suppuration in the duct of Bartholin or in the other glandular structures should be treated by dissecting out the distended sac. If this is not done the next best thing is to incise it freely, dry it out, paint the interior with tincture of iodin and pack it with iodin gauze. **Abscess** of the vulva should be incised widely, its interior dried out, and packed with gauze. The packing should be changed daily.

The treatment of these conditions by means of suction hyperemia is very effective.

Tuberculosis and **syphilis** of the vulva are treated the same as in other parts.

Gonorrhea of the vulva and vulvovaginitis require special treatment (see Gonorrhea, page 283).

Pruritus vulvæ is discussed under skin diseases (see Vol. I, page 843).

Tumors.—*Papillomata* of non-specific character should be treated by removing the cause. If there is irritating discharge treatment should be directed to its cure. All sources of irritation having been removed, the parts should be kept dry and dusted with some antiseptic powder. A mixture of equal parts of salicylic acid and stearate of zinc is effective. Calomel powder is also used. Iodoform powder mixed with collodion may be painted on the warts. Subgallate of bismuth and boric acid, equal parts, are of value

When such treatment fails, the tumor-bearing area may be excised and the wound closed (see Warts, Vol. I, page 841).

Urethral caruncle, if small and giving rise to no symptoms, does not require treatment. Angiomatous caruncle is best destroyed by means of a small thermocautery point. Painful caruncle should be excised with the knife as though it were a malignant tumor. Unless wholly removed these growths are prone to return. Operation can be done under local anesthetic, but a more satisfactory exposure can be secured and a more facile operation done under general narcosis.

In excising a caruncle an elliptic resection of the tissue should be made. The bleeding is apt to be profuse. Spurting vessels should be tied. The fine sutures used to close the wound will control the venous and capillary bleeding. The urine should be rendered non-irritating.

Cysts of the vulva, usually originating in the glands of Bartholin, should be excised as a tumor without opening the cyst. After the sac has been extirpated, the wound should be closed from the bottom. This may be done without drainage if a clean operation has been performed (see Cysts, Vol. I, page 325).

Hydrocele should be treated by cutting down upon the sac with all of the care as for operation for hernia. The sac should be excised. This is easily accomplished by blunt dissection. If it communicates with the peritoneal cavity the neck should be ligated in the inguinal canal. If hernia is present it should be operated upon at the same time. It is possible to cure hydrocele in the female by means of any of the operations employed in the male, but excision is so simple and effective that it is preëminently the operation of choice.

Lipoma, *fibroma* and other benign tumors are easily excised. *Angioma* should be excised, or, if extensive treated by electropuncture.

Carcinoma and *sarcoma* should be treated by immediate excision (see Tumors, Vol. I, page 327).

Hypertrophy of the Clitoris.—Amputation of the clitoris is called for when its hypertrophy is so great as to be a source of annoyance or lead to sexual perversions. Unless there are unpleasant symptoms clitoridectomy should not be advised. Complete or partial amputation may be done. In the former, an incision is made through the mucous membrane around the organ and joined above by a straight median incision. The enveloping structures are dissected back and the clitoris separated from its attachments under the pubic arch and removed. The wound is closed by deep and superficial sutures. This simple operation should be done with the utmost aseptic care as infection of the deep tissues is a matter of much gravity. Clitoridectomy besides being done for hypertrophy, is performed for tumor of the clitoris. I have had a clitoridectomy for carcinoma followed by infective phlebitis of the iliac vein which nearly cost the patient her life.

Adhesions of the Prepuce of the Clitoris.—This very common condition, giving rise to the retention of secretions, is remedied by separating the adhesions by means of a blunt instrument such as a small probe. The operation can be done without anesthesia except in very sensitive children. Powder or ointment should be applied to prevent recurrence of adhesions after the operation.

Imperforate Hymen.—Incision of the bulging hymen in the median line without anesthesia is all that is required. The condition should not be confused with atresia of the vagina. A *dense hymen* may present an opening so small as to preclude coitus and require incision for the purpose of enlarging the introitus.

Vaginismus.—This symptom requires for its cure the removal of the pathological condition which causes it. The most painstaking search should be made for sources of irritation, both local and remote. Inflamed hymen or labia, fissure or abrasion, urethral caruncle, neuroma, kraurosis or anal fissure should be cured. If due to an unusually small introitus or a large penis, dilatation of the former may be required under general anesthesia.

The general health of the patient should be looked to. Attempts at coitus should be interdicted if there is local irritation. If no local cause can be found, dilatation of the introitus should be practised. This may be done at one sitting under general anesthesia or gradually at regular intervals. Local anesthetization may be secured by placing a pledget of gauze, soaked with 5 per cent. cocain solution, at the introitus.

In cases which do not yield to the above measures plastic enlargement of the orifice should be done. An incision is made in the median line at the posterior part of the vaginal orifice. This incision should pass 2 cm. (¾ inch) into the perineum and extend for 2.5 cm. (1 inch) up the vagina The cut muscle should be allowed to gap, while the mucous membrane is dissected free for a short distance on either side of the wound and sewed across the gap. The wound should be dressed with a plug of gauze in the introitus.

Fissure of the Vulva.—The cure of this condition is the same as that for fissure of the anus. In most cases the region should be anesthetized with cocain, the fissure should be incised, and then cauterized with silver nitrate. Coitus should be interdicted until a cure is secured. If necessary the silver stick may be applied a second or third time. Its application should be followed by a mild dusting powder.

Hypertrophy of the Labia Minora.—When extreme, amputation of the enlarged labia is called for.

Elephantiasis of the Vulva.—Local treatment of abrasions and ulceration is first called for. Syphilis should be eliminated. The only curative treatment after the above measures consists in amputation of the hypertrophied structures. The condition should be treated as two pedunculated tumors. The parts should be shaved. The mass on one side should be lifted forward and its base transfixed with a stout ligature. By transfixing, tying, and cutting just beyond the ligature, as the operation proceeds, blood may be saved in what otherwise would be a very bloody operation. If the operation must be done in the presence of unhealed ulcerations they should be sterilized by the actual cautery or with iodin.

Varicose Veins of the Vulva.—The obstruction to the return of the venous blood should be removed if possible. If no symptoms are present operation is not necessary. If the veins are near the surface and the skin is thin, operation should be done. The patient should be instructed to make local pressure if a vein should rupture. The operation consists in ligating and dissecting out the veins, either singly as for varicose veins of the leg, or *en mass* as for angioma.

Kraurosis of the Vulva.—Palliative treatment is similar to that for pruritus. The ordinary simple measures are apt to be ineffective. Pure phenol, followed by alcohol, gives relief for a time. An ointment of 1 per cent. of yellow oxid of mercury, or phenol ointment (3 per cent.), or hot applications may be tried.

Of the operative measures forcible dilatation of the contracted vulvar orifice gives relief for a while. The operative excision of the diseased skin and underlying connective tissue is the only positively curative procedure.

Excision of the Vulva.—This operation is performed for kraurosis, angioma, epithelioma, papillomata, etc. The parts should be shaved and

cleansed. An incision should be made around the diseased area at a distance sufficient to insure against recurrence. The incision should pass through the skin, superficial fascia, and if necessary deeper, to go beyond the level of the disease. Assuming that the whole vulva is involved in the disease, an oval incision should pass about the whole area. A second incision should be made about the urethral orifice, within the diseased area (Fig. 1733). If the urethra is involved in an epitheliomatous growth, it should be amputated above the disease. A third incision should be made within the vagina, far enough to escape the disease. The whole area of disease-bearing tissue should then be dissected away (Fig. 1734).

Bleeding vessels are tied. The vagina and urethra are dissected free for a short distance. The skin is sutured across the wound, the sutures catching

FIG. 1733.—EXCISION OF VULVA.
Showing incisions around whole vulvar area, external urinary meatus, and vagina.

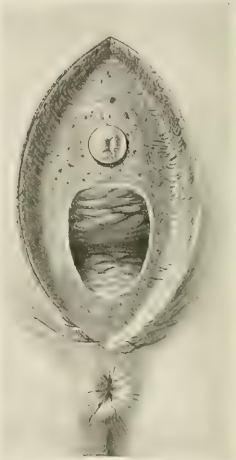


FIG. 1734.—EXCISION OF VULVA.
The diseased vulva has been removed.

the underlying wound tissues. The edges of the urethra and of the vagina are sutured separately to the skin (Fig. 1735).

In some cases of excision for epithelioma, so wide an area will have been denuded that additional incisions, to make sliding flaps, must be made in order to cover the defect.

Vesical sphincteric incontinence in the female requires repair of the ruptured perineum, relaxed vagina and prolapsed uterus. Anterior colpoplasty, such as is done for cystocele, suffices in some mild cases. Other mild cases may be cured by tightening the sphincter by means of an infolding suture (Figs. 1735*a* and 1735*b*). In aggravated cases the urethra must be dissected free and the base of the bladder tightened by the application of sutures so placed as to shorten the sphincter. This is done through the roof of the vagina. In closing the wound the urethra may be rotated upon its long axis

sufficiently to cause still further tightness of the internal meatus. Lifting up the sunken bladder through a suprapubic wound and approximating its base toward the pubes by means of sutures has been of service. The use of a compressing vaginal pessary is a last resort. Paraffin injections around the urethra have succeeded in some cases which defied every other method of treatment.

Transvaginal rectal drainage of the bladder is useful, when these operations fail. The rectal sphincter is thus substituted for the deficient vesical sphincter. A vesicovaginal fistula and a rectovaginal fistula are made and the vaginal entrance closed (page 352). This creation of two fistulæ and the performance of colpocleisis, described below, have been done with excellent success.

Urethrorectal anastomosis may be done if the preservation of the sexual activity of the vagina is desired. Instead of the creation of fistulæ and closure of the vagina, the urethra may be dissected free, carried to the side of the vagina, and implanted in the rectum just above the internal sphincter. This is accomplished by making an incision on one side of the introitus vaginæ from the urethra to the perineum. The urethra is circumscribed and dissected free throughout its whole length. The dissection is carried upward external to one side of the vaginal wall as far as the bladder and rectum. The urethra is placed in the lateral wound, sewed into an opening in the rectum, and the wound closed.

FIG. 1735.—EXCISION OF VULVA, SHOWING WOUND CLOSED.

Prolapse of the Urethra.—This condition, which strangely is found most commonly in children, is probably due to neuromuscular deficiency, and is rarely cured by nonoperative treatment. Astringents, mechanical support, and caustic applications offer poor hope of relief, compared with operation. The prolapse is essentially a prolapse of the mucous membrane of the urethra, dragging with it the mucous membrane of the bladder. In some cases the surgeon can reduce the prolapse by pressing the prolapsed mucous membrane back with the finger. In such cases it will often be found that the dilatation of the peri-urethral structure is so great that the finger easily passes into the bladder. When this is done an incision should be made in the median line of the anterior vaginal wall along the whole length of the urethra. This should pass down to the mucous membrane of the urethra throughout its whole length, dividing both the internal and external urinary sphincters. If the urethral mucous membrane is hypertrophied and greatly redundant, a longitudinal strip may be resected from the floor.

The operation should then proceed as the operation for sphincteric incontinence in the bladder or rectum. Sutures should be passed into the wound deeply enough on either side to catch the per-urethral tissues for an extent of fully one-half of the circumference of the urethra. This suturing should be interrupted and done with chromicized catgut. It should extend from the bladder to the external meatus. A small self-retaining rubber catheter should be passed and the sutures tied down while it is in place. The sutures which catch the sphincters should not involve the vaginal mucous membrane;

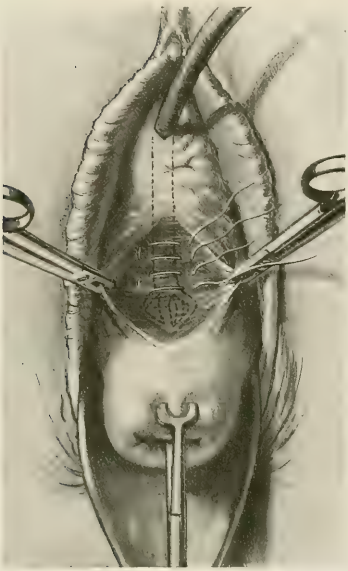


FIG. 1735*a*.—OPERATION FOR SPHINCTERIC INCONTINENCE OF BLADDER.
Two mattress sutures catch the vesical sphincter. A self-retaining catheter is placed in the bladder.

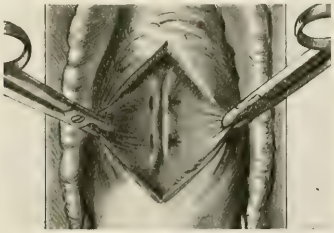


FIG. 1735*b*.—OPERATION FOR SPHINCTERIC INCONTINENCE OF BLADDER.
Showing the two mattress sutures tied.

the other sutures may. This operation has the merit of not bearing the name of any one. I have done it with much satisfaction. It is the natural procedure that would occur to any surgeon.

If a strip of urethral mucous membrane is removed the sutures should just catch the edge of the mucous membrane but should not penetrate the internal mucosa. In aggravated cases it will be best to catch even more than half of the periurethral tissue. Even in mild cases the surgeon should not be satisfied to operate upon the external sphincter alone. In such cases it is better to perform the complete operation. In any case the sutures should catch the outer layer of the mucous membrane and make it fast to the surrounding tissue. In doing this the mucous lining of the urethra should be pushed up even farther than its normal position in order that slight overcorrection should be secured.

THE VAGINA

Traumatisms of the Vagina.—*Hematoma* adjacent to the vagina may usually be checked in its development by means of pressure or cold applications. The patient should be kept in bed. When the development of the hematoma has ceased, it may usually be expected to be absorbed. If absorption has not taken place in a week, or if evidences of infection of the clot are present, the tumor should be incised, the blood cleaned out and the cavity packed with gauze. The packing should be renewed every day or two until the cavity has become obliterated.

Wounds, not due to childbirth, should be sewed if they are not badly infected or associated with injury which may result in sloughing. Hemorrhage is one of the serious dangers, and a careful search should be made to discover the extent of the injury and catch bleeding vessels. If the wound communicates with the peritoneal cavity the vagina should be drained with a gauze packing. *Ruptures of the perineum* should be sutured just as those due to parturition. Wounds should be sutured with care to unite each severed structure. In complete tears through the rectovaginal septum pains should be taken to bring into apposition the torn sphincter muscles as well as the several torn structures. Immediate suture of these wounds is to be recommended.

Puerperal Injuries of the Pelvic Outlet.—*Laceration of the perineum*, occurring in childbirth, should be repaired as soon as possible after the delivery. If done within a few hours the parts are so benumbed from the stretching and pressure that an anesthetic is not required. If there is infection, eclampsia, or other serious complication, the operation should be deferred. In complete lacerations or lacerations involving the sphincter of the anus an immediate operation may be done even though the assurances of success are not present. The surgeon will often be surprised to see how well these injuries heal under primary suture when healing is but little expected. Indeed, such lacerations often heal without suture and without any treatment other than keeping the patient's thighs close together.

The *primary operation* should be done with every aseptic formality. It is a common mistake to apply these primary sutures in an informal way, with the patient lying in bed, and with little attention to aseptic details. The operation should be done with attention to every detail. It is best that the patient should be transferred to a table (an ordinary kitchen table will do) which should be located with reference to securing the best light. The parts should be shaved and cleansed (see Treatment of Wounds, Vol. I, page 166). If an anesthetic is necessary it should be given. The vagina should be irri-

gated with sterile water to remove clots. The uterus should be caused to contract.

The patient's legs should be supported, with thighs and knees flexed, by means of leg supports. The field of operation should be surrounded by sterile covers. For this purpose clean sheets may be spread over the legs and abdomen and the area immediately about the vulva covered with towels or a perineal protector. The surgeon should be seated at the foot of the table facing the perineum. He should be comfortable and conscious that he is going to do a good job.

Retractors should be introduced to facilitate inspection. Lacerations of the cervix which require suture should be closed with chromic catgut. The closure of cervical wounds should not encroach upon the cervical canal. A tampon of gauze should then be placed against the cervix to keep the field of operation dry. This should be removed after the perineum has been sutured. It should be the surgeon's business to remember that this tampon is to be removed. To forget it, is to invite failure, if nothing worse.

Tears of the vaginal wall should be sutured with chromic catgut. Lacerations of the perineum should be exposed by retracting the mucous membrane and skin. The ruptured muscles should be brought together by interrupted sutures of chromic catgut applied with a curved needle, and tied in the same manner as for plastic secondary operations (see below). The closure of the muscular rent should be a subcutaneous operation unless the tear is a superficial one. If it is superficial it may be closed with interrupted sutures about 1 cm. ($\frac{1}{3}$ inch) apart and placed about 0.75 cm. ($\frac{1}{4}$ inch) from the edge of the wound. The sutures should pass well back to get a good hold of the muscle. After having united the muscle separately by means of three or four deep buried sutures, the mucous membrane and skin should be closed by a subcuticular suture or a running superficial suture. The surgeon should see to it that exact appositions of the superficial parts are secured.

In case of complete laceration through the perineum into the rectum, the mucous membrane of the rectum should first be sutured. No knots should be tied in the wound. The knots should be left on the rectal side. Having sewed the rectal mucous membrane, the wound should again be irrigated with warm salt solution, and then the torn muscles united by interrupted sutures. The most important of these is the sphincter ani. Being a circular muscle, it retracts widely, and its ends will be found in a cavity on either side close under the skin. These ends should be grasped by forceps, drawn together, and sutured with chromic catgut. The ruptured muscle bundles of the perineum and vulva should then be sutured, and over all the mucous membrane and skin.

A sterile pad should be placed on the wound and the patient kept quietly in bed. The bladder should be emptied by catheter for the first forty-eight hours. After that the vulva should be irrigated with boric acid solution after each urination. Following repair of the sphincter ani, the bowels should not be moved until the third day and then by means of a high enema of sterilized olive oil. The diet of the patient should consist of foods having the least residue. If nonabsorbable sutures have been used, they should be removed about the tenth day. The patient should be kept in bed for two or three weeks.

As the patient lies in bed the perineal wound should be kept dry. This is best done by richly powdering it with stearate of zinc and boric acid. This powder should be renewed after each irrigation. A dry gauze pad keeps the skin surfaces apart. (For more accurate anatomical details of the primary operation, see plastic operation, below.

Lacerations of the perineum may be sutured between the second day and the second week while the wound is covered with granulations. This is called *intermediary suture* and is to be recommended only in superficial tears. It is the same as *secondary suture* in other wounds.

Plastic operation for repair of the perineum is performed after cicatrization of the wound has taken place. The operation is done after the products of inflammation have become absorbed and the parts are pliable. A plastic

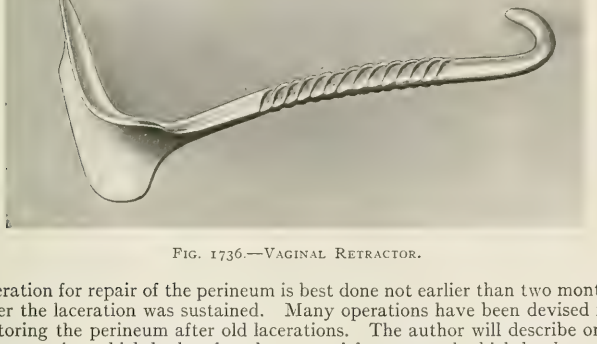


FIG. 1736.—VAGINAL RETRACTOR.

operation for repair of the perineum is best done not earlier than two months after the laceration was sustained. Many operations have been devised for restoring the perineum after old lacerations. The author will describe only the operation which he has found most satisfactory, and which he does not know to bear any one's name.

Before operating, the patient should have had her bowels well evacuated, and should have been placed upon a diet having the least unabsorbable

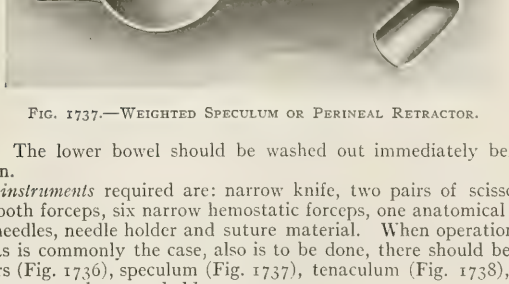


FIG. 1737.—WEIGHTED SPECULUM OR PERINEAL RETRACTOR.

residue. The lower bowel should be washed out immediately before the operation.

The *instruments* required are: narrow knife, two pairs of scissors, two mouse-tooth forceps, six narrow hemostatic forceps, one anatomical forceps, curved needles, needle holder and suture material. When operation on the cervix, as is commonly the case, also is to be done, there should be added: retractors (Fig. 1736), speculum (Fig. 1737), tenaculum (Fig. 1738), uterine dilators, curets and sponge holders.

The patient should be placed in the *perineal position* (page 54, Fig. 1495). The pudendal hair should have been shaved. The vagina should be washed out with a stream of sterile water, while a sponge holder, carrying a gauze tampon smeared with soap, is used to cleanse the vaginal cavity.

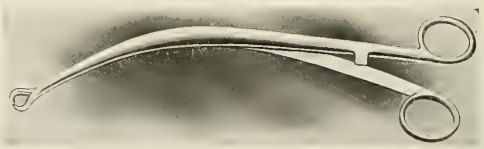


Fig. 1738.—Tenaculum Forceps.

The soapy water should all be washed away with a stream of sterile water. The feet, legs, and abdomen of the patient should be covered with sterile protectors. Only the vulva and perineum should be exposed to the surgeon. One assistant should stand on either side. Instruments and sponges can best be handed from above across the pubes. Any operation to be done upon

Fig. 1739.—Perineal Position.

the uterus or cervix should be performed first. In many cases trachelorrhaphy is required. If operation for cystocele is necessary, it should come between the operations on the uterus and perineum.

The *operation* in a case of incomplete laceration, is begun by catching the

edges of the vulvar orifice at the line of the hymen on either side with a clamp. These clamps should be placed opposite one another and represent the upper limit at which it is desired to unite the two sides of the dilated introitus.

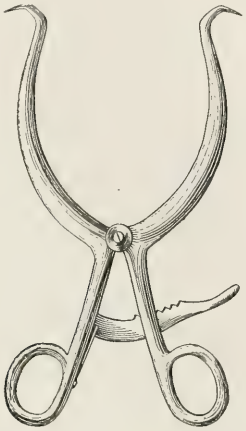


FIG. 1740.—TENACULUM RETRACTOR.

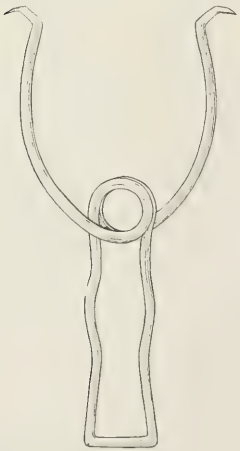


FIG. 1741.—SELF-RETAINING SPRING TENACULUM RETRACTOR.

Instead of clamps the surgeon may use one of the special retractors made for that purpose (Figs. 1740 and 1741). A third clamp is applied to the edge of

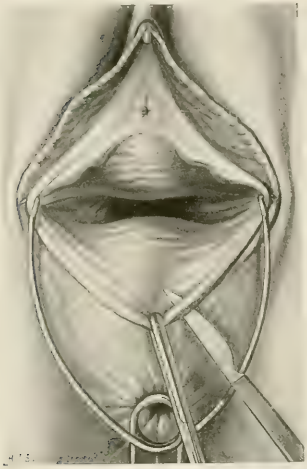


FIG. 1742.—PERINEORRHAPHY (FIRST STAGE).
A narrow strip of tissue is cut away to provide an opening to the perineal tissues. Retraction of the vulva is made by a self-retaining spring-hook tenaculum.

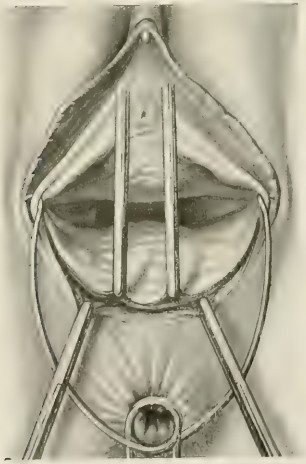


FIG. 1743.—PERINEORRHAPHY (SECOND STAGE).
Clamps are applied, ready for the dissection.

the orifice at the middle line posteriorly. These clamps are applied in order to secure symmetry in the initial incision. An assistant picks up the clamps while the surgeon cuts away a narrow strip of tissue about the lower and lateral borders of the vulvar opening, leaving the lateral or tenaculum clamps attached above the wound and carrying away the middle clamp with the strip of tissue (Fig. 1742). Two clamps are then attached to the upper edge of the wound and a clamp on either side to the lower edge (Fig. 1743). The two upper clamps are held by assistants. The lower clamps on the edges of the wound are held alternately by the surgeon as he proceeds with the denudation and exposure of the torn muscle and fascia. Partly by blunt dissection and partly with a knife or scissors the surgeon dissects between the rectum and vagina and laterally toward the tuberosities of the ischia (Fig.

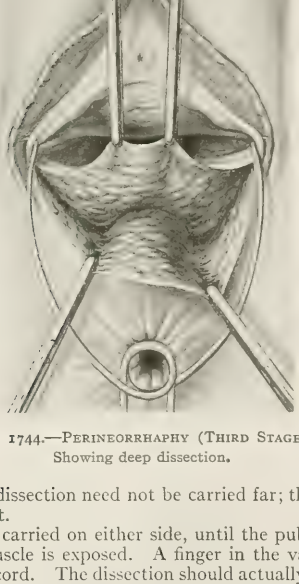


FIG. 1744.—PERINEORRHAPHY (THIRD STAGE).
Showing deep dissection.

1744). The median dissection need not be carried far; the lateral dissection is the more important.

The dissection is carried on either side, until the pubococcygeal portion of the levator ani muscle is exposed. A finger in the vagina identifies this as a rounded edge or cord. The dissection should actually expose the muscle. Care should be taken not to penetrate rectum or vagina. If either mucous membrane is punctured, the wound should be closed by a fine suture, applied on the raw side and not penetrating the mucous membrane.

A triangular piece is then cut out of the posterior wall of the vagina, its base downward, and its size depending upon the amount of rectocele present. The upper lateral clamps are removed (Fig. 1745).

The surgeon now takes in a holder a curved needle, carrying heavy chromicized catgut. The pubococcygeal muscle is lifted forward with ring

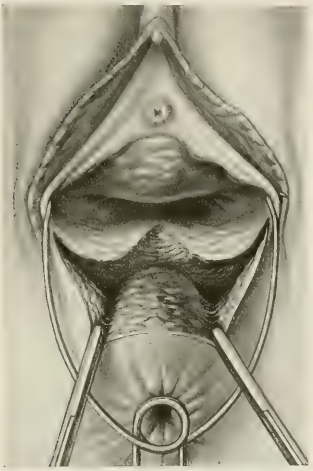


FIG. 1745.—PERINEORRHAPHY (FOURTH STAGE).
The deep dissection has been completed. A triangular piece is cut out of the posterior vaginal wall.

FIG. 1746.—PERINEORRHAPHY (FIFTH STAGE)
Deep buried sutures are applied.

forceps, or it may be caught in the depth of the wound with the needle. This is passed deeply into the lateral aspect of the wound toward the tuberosity of the ischium, then toward the rectum, and emerges in the wound. It then passes in front of the rectum, catching the tissue in the middle line, and takes a reversed course on the other side. Three or four of these deep sutures are inserted from above downward. The two remaining clamps are removed (Fig. 1746). The deep sutures grasp the separated fibers of the levator ani muscle. The surgeon keeps an index-finger in the vagina while inserting them. A running submucous suture is then applied to the triangular wound in the posterior vaginal wall. This suture is carried down as far as the fourchette and the end left long.

FIG. 1747.—PERINEORRHAPHY (SIXTH STAGE).

Deep sutures tied. This closes the deep parts of the wound, brings together the torn muscle, and leaves only a superficial wound to be closed.

FIG. 1748.—PERINEORRHAPHY (SEVENTH STAGE).

Operation completed by subcuticular suture, the ends of which are tied within the wound and buried. In some cases some extra-lateral sutures must be applied.

The wound is then dried out and the deep essential sutures tied from above downward. As these sutures are tied it will be observed that the tissues from either side are drawn across between the rectum and vagina, and a perineal body built up. The sutures should be tied well, the knot being held by forceps between the first and second turns. The tying of these sutures is a most important step, and should bring the tissues snugly together (Fig. 1747).

There remains now only to close the superficial external wound. The small crushed edge of skin where clamps have been should be cut away. An angle of skin at the lower median aspect of the wound should be cut out to prevent puckering. A subcuticular suture is begun at the lower angle of the wound. This proceeds upward until the fourchette is reached. The suture is tied to the submucous suture used to close the vaginal wound and the

knot sinks from sight (Fig. 1748). Instead of a subcuticular suture, interrupted sutures or a running suture may be employed. Rarely does a bleeding vessel require to be ligated.

In *cases with rupture of the sphincter ani*, the two ends of the sphincter may be exposed by deepening the perineal dissection. They may then be grasped with clamps, brought forward (Fig. 1749) and united by two or three sutures of chromicized catgut (Fig. 1750). This having been done the perineorrhaphy proceeds as above.

In order to prevent giving way of the sutures in the sphincter ani, the aftercare of the bowels is important. A diet having the least residue should be used—such as albumin water, glucose and grape juice. After three or four days castor oil should be given, followed in four hours by a high enema.

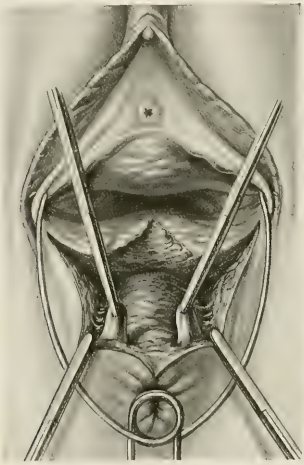


FIG. 1749.—PERINEORRHAPHY FOR COMPLETE LACERATION.
The perineum has been dissected and the ends of the torn sphincter ani are seized by clamps and drawn forward for suturing.

The patient should be instructed not to strain. Olive oil should be added to the diet and the bowel should be washed out every second day. After two weeks have elapsed the patient may resume her usual diet.

In *old complete lacerations of the rectum* the operation is the same as the above. No opening is made into the rectum, but the separated sphincters are reached by dissecting through the U-shaped perineal wound. It is rarely necessary to add a downward and outward incision at either side of the anus.

Rectocele (Posterior Colpocele).—Operation for rectocele precedes and becomes a part of operation for repair of the lacerated perineum. The preparations and instruments are the same. The field is exposed as for perineorrhaphy. If cystocele is present a flat retractor should lift up the anterior vaginal wall. After the U-shaped incision has been made or the U-shaped

strip cut from the vulvar orifice, the dissection is proceeded with as for simple perineorrhaphy. The posterior wall of the vagina is seized in the median line by forceps at the upper part of the rectal bulge into the vagina. Usually this will be about midway between the introitus and the cervix. From this point an incision is carried on either side downward and slightly outward, including between them a triangular segment of the posterior wall, the removal of which will reduce the caliber of the vagina to the desired size. This triangle is dissected out, and the gap closed by interrupted sutures of chromicized catgut. The operation does not differ from that for ordinary perineorrhaphy excepting that a larger triangle of vaginal wall is removed. It is called *colpoperineorrhaphy*.

FIG. 1750.—PERINEORRHAPHY FOR COMPLETE LACERATION.
The sphincter ani has been sutured. The rest of the operation proceeds as the usua perineorrhaphy.

Cystocele (Anterior Colpocele).—Relaxation and bulging of the anterior vaginal wall into the vagina requires operation when the cystocele causes mechanical interference with the functions of the bladder or vagina. A moderate degree of cystocele is cured by repair of the perineum. Cystocele in which the perineum is not at fault often requires operation. The operation of *anterior colpoplasty* is applicable to cases in which the disease is largely a matter of relaxation of the vaginal wall. It is performed as follows:

The patient is prepared as for perineorrhaphy. Any operation required upon the uterus is first done. A weighted perineal retractor exposes the anterior vaginal wall. A toothed clamp is applied to the middle line of the anterior vaginal wall about half 1.25 cm. (1 inch) from the external urinary meatus. A second clamp is applied in the middle line at the upper part of the cystocele; usually this is as near the cervix as can easily be reached. Two lateral clamps are then applied at such distances apart as to include

within the four clamps an area, the removal of which will take up the slack in the bulging anterior vaginal wall. The points marked by the clamps are then connected by an incision which should pass through the whole thickness of the vaginal wall. This diamond-shaped quadrilateral area should then be resected. This is quickly done without danger of wounding the bladder as the vaginal wall is not thin, and there is a connective-tissue space between it and the bladder which renders dissection easy.

The bladder should then be dissected free for a short distance around the wound. The dissection toward the vesico-uterine space should be carried farther—in pronounced cases, as far as the vesico-uterine peritoneum. The bladder floor should then be pressed upward and backward and fastened to the anterior surface of the uterus by a couple of sutures. This does two necessary things; it lifts up the bladder floor and holds the uterus forward. In aggravated cases the operation should be the same as that for prolapsus uteri (*q.v.*).

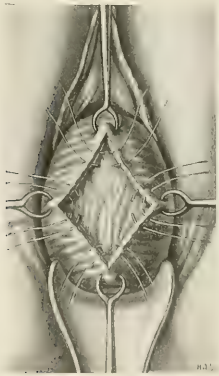


FIG. 1751.—ANTERIOR COLPORRHAPHY.

The diamond-shaped area is closed by sutures beginning at the corners.

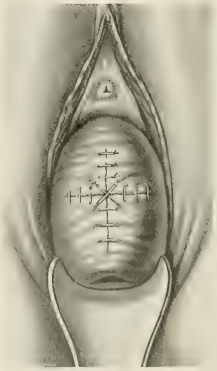


FIG. 1752.—ANTERIOR COLPORRHAPHY.

Result after closure of diamond-shaped wound.

The wound is closed as follows: A running suture of chromicized catgut is begun at each angle where a clamp is located (Fig. 1751). Each suture takes up the vaginal wall on either side of the clamp. Thus the four sutures work toward the center of the denuded area, at which they finally meet. As the sutures pass across the denuded area the bladder wall is caught up for the purpose of eliminating blood-holding spaces. The sutures having been tied, the ends of each opposite pair at the center are tied together to strengthen the union (Fig. 1752).

By this operation the vaginal wall is shortened in both dimensions. In cases in which shortening of the vagina is undesirable on account of its tendency to produce retroversion of the uterus, the resection should be in the form of an oval, and the wound should be closed as a single median line. When this is done the continuous suture should be interrupted at several places.

Following the operation the perineum may receive any needed attentions. A pad of sterile gauze should be applied to the vulva, and the patient should be kept in bed two or three weeks.

G. R. White (Jour. Am. Med. Assoc., Nov. 20, 1909) showed that simple colpoplasty is not effective in curing real cystocele, *i.e.*, the condition in which the anterior vaginal wall is torn loose from its suspending attachments. It is obvious that simply to narrow the caliber of a tube will not throw its wall further out from its center, but rather will tend to do just the opposite. The principle of the operation which he devised consists in attaching the anterior vaginal wall to the *white line* of the pelvic fascia from which it has been torn. The white line is the place of the upper insertion of the levator ani into the pelvic fascia. It lies immediately external to and above the vagina, and extends from the spine of the ischium to the symphysis pubis. White describes the principles of his operation as follows: The vagina is held open by retractors and the spine of the ischium located by palpation. An incision 2.5 or 5 cm. (1 or 2 inches) long is made through the vaginal wall from a point opposite the spine of the ischium toward the symphysis. This in-

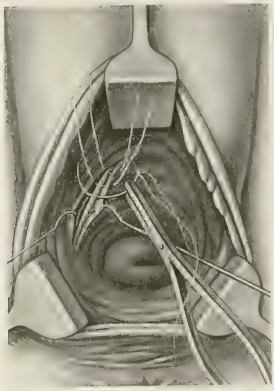


FIG. 1753.—OPERATION OF G. R. WHITE FOR CYSTOCELE.
Curved needle catches the white line in the depth of the wound.

cision follows the course of the white line. It begins about opposite the cervix and passes down toward the side of the urinary meatus. The bladder is separated from the vagina by blunt dissection until the spine of the ischium and the white line are reached and can be felt by the finger. The wound is then retracted and a suture passed back of the white line close to the spine of the ischium. This may be introduced with a sharply curved needle passed eye-first to prevent bleeding. The needle is then passed through the corresponding lip of the vaginal wound. A second needle on the other end of the suture is passed through the opposite lip of the vaginal wound. A second and third similar suture are placed 1.25 cm. ($\frac{1}{2}$ inch) apart lower down. If there is prolapse of the vagina a fourth suture is placed still below this, catching the fascia as it passes up under the pubes. The opposite side is treated the same. When the sutures are tied the vaginal wound is closed

and the vagina is found to be drawn upward and outward and attached to the pelvic fascia (Fig. 1753). The operation is usually done in connection with other plastic work. This is the rational treatment of cystocele, and I am persuaded that it is destined to supplant the old and commonly ineffective operation of anterior colpoplasty or colporrhaphy. In this operation White enunciated an entirely new principle in the treatment of this condition.

Vesicovaginal Fistula.—Operation offers the only cure for old vesicovaginal fistulas. Success in the operation depends upon the most scrupulous attention to surgical details. There are operations in which successful results may be secured despite slipshod methods; not so with vesicovaginal fistula. This is an operation which proves the surgeon.

There are certain fundamental principles to be observed: The urine should be rendered nonirritating and mildly antiseptic by the exhibition of drugs for those purposes. Exceptionally good light should be had upon

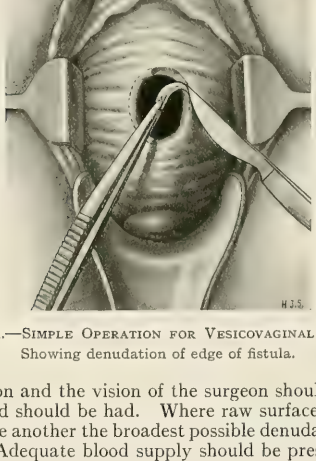


Fig. 1754.—Simple Operation for Vesicovaginal Fistula.
Showing denudation of edge of fistula.

the field of operation and the vision of the surgeon should be good. Ample exposure of the field should be had. Where raw surfaces are to be exposed for apposition to one another the broadest possible denudation and apposition should be made. Adequate blood supply should be preserved in all tissues to be united. Blood clots and other foreign material should be removed from the surfaces to be united. Devitalization of the surfaces by mechanical and chemical insults should be avoided. The appositions should be exact. Suture material should be that which produces the least irritation. Undue tension should be avoided. After the operation the wound should be protected from tension and irritation.

Much success has been secured by the simple *denudation operation* in cases in which examination shows that the edges of the opening can be brought together easily and without tension. The patient is placed in the perineal position. The perineum is retracted by a large weighted speculum. A tenaculum grasps the cervix and draws it downward to bring the anterior

vaginal wall more prominently into the field. (Some surgeons prefer the lateral position, others the knee-breast posture.) The surgeon should determine in which direction there is the greatest laxity of tissue and should calculate to make the line of closure at right angles to it. Usually it will be determined to draw the tissues directly from the sides, and to make the union in the median line The margin of the opening is picked up with fine mouse-tooth forceps, and with a sharp narrow knife the edge of the fistula is pared away. This freshening of the opening should be made obliquely so that more from the vaginal than from the bladder side is taken away. The denudation should extend into the vesical mucous membrane. The degree of obliquity should depend upon the thickness of the vesicovaginal septum: the thinner, the more oblique. To leave a bit of mucous membrane upon the wound surfaces insures failure. The denudation should be brought to a point at each end (Fig. 1754). The width of the denudation should not be less than 0.65 cm. (¼ inch). The sutures should emerge through the vaginal mucosa about 0.65 cm. (¼ inch) from the edge of the wound. There should be about two sutures to every 1 cm. (five sutures to every 2.5 cm.). The best suture material is silver wire which should be passed with a fine curved needle. Or fine silkworm-gut may be used. The sutures should pass

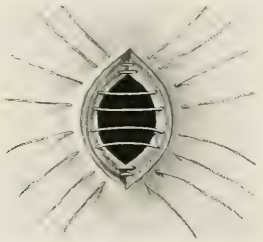


FIG. 1755.—SIMPLE CLOSURE OF VESICOVAGINAL FISTULA AFTER DENUDATION OF EDGE.

just to the vesical mucosa but should not penetrate it. The sutures should be interrupted, and each one tied separately (Fig. 1755).

If a denudation as wide as 1.25 cm. (½ inch) has been secured without prospect of tension, the vaginal mucous membrane may be undermined for a distance of 0.8 cm. (⅓ inch) around the opening, and a continuous suture of well-chromicized catgut used to close the opening. This is called the *flap-splitting operation.* The first suture should embrace all the tissues except the vesical and vaginal mucous membranes. It should be snugly drawn up and tied beneath the mucous membrane. Over it the mucous membrane should be closed with a separate suture which may be a submucous suture, or a through-and-through running suture (Figs. 1756 and 1757).

In cases in which there is not great laxity of tissue a more formal flap-splitting operation should be done. A notch should be cut out of the whole thickness of the vesicovaginal septum at either end of the ultimate line of closure. The margin of the fistula is then split around its whole circumference, the dissection being carried between the vaginal wall and the bladder for at least 1.25 cm. (½ inch) in every direction. The bladder opening is closed by a running suture of chromicized catgut, embracing all of the

bladder wall except the mucosa. Over this the vagina is sutured separately with a submucous suture or a through-and-through suture.

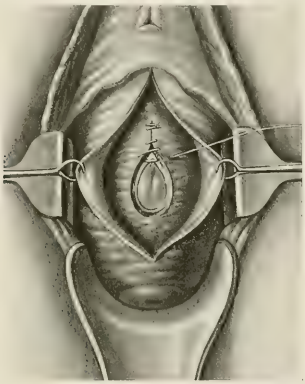


FIG. 1756.—FLAP-SPLITTING OPERATION FOR VESICOVAGINAL FISTULA.
Closure of bladder wall with continuous suture. Note that the suture does not involve mucous membrane either of bladder or vagina.

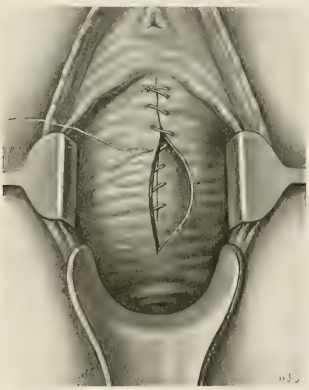


FIG. 1757.—FLAP-SPLITTING OPERATION FOR VESICOVAGINAL FISTULA.
The bladder wall has been sewed. Note that the wound in the vaginal wall is not a median wound but has one lateral lip longer than the other. When the vaginal wall has been sewed the line of suture will lie at one side and not be imposed upon the line of suture of the bladder wall.

C. H. Mayo (Annals of Surg., January, 1916) described a satisfactory and ingenious operation, which for the ordinary fistula should be most

effective. A circular or oval incision is made in the vaginal mucous membrane about 5 mm. ($^3/_{16}$ inch) from the opening, completely around the fistula. The mucous membrane is dissected toward the fistula, but care is taken not to break through its wall. This dissection should not approach too near to the fistula, and should penetrate as far as the bladder mucous membrane, but not through it. This converts the fistula into a tube with a funnel of vaginal mucous membrane at its lower end (Fig. 1758). A ligature carrier is then passed through the urethra into the bladder, and thence through the fistula into the vagina. A silk suture is passed through both sides of the vaginal mucous membrane funnel and threaded through the eye of the carrier. The carrier is then drawn out through the bladder. The ends of the suture passing out through the urethra are drawn upon

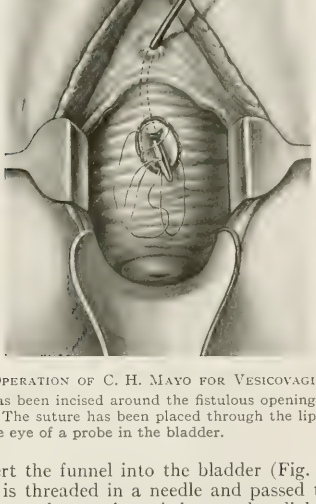


FIG. 1758.—OPERATION OF C. H. MAYO FOR VESICOVAGINAL FISTULA.

The vaginal wall has been incised around the fistulous opening, and the mouth of the fistula dissected free. The suture has been placed through the lips of the fistulous tract, and passed through the eye of a probe in the bladder.

and caused to invert the funnel into the bladder (Fig. 1759). One of the ends of the suture is threaded in a needle and passed through the skin of the labia. The two ends are then tied to make slight traction. A self-retaining catheter is placed in the urethra to drain the bladder. The vaginal wound is then closed with a purse-string suture.

The patient should lie on her side or face to facilitate drainage. The catheter must be kept clean. Irrigation may be necessary. By the end of a week the healing is usually solid, but the patient should be kept quiet for two weeks. The suture comes away itself, or it may be cut and pulled out.

In cases with destruction of a part of the urethra, giving rise to *urethrovaginal fistula*, the same general principles apply. It is important to dissect back far enough to gather together the muscular fibers of the sphincter of the bladder which has partly been destroyed. The vesicovaginal opening should be closed by the usual methods. If the destruction of urethra is not

FIG. 1759.—OPERATION OF C. H. MAYO FOR VESICOVAGINAL FISTULA.

Diagram showing inversion into the bladder of the fistulous tract brought about by drawing the suture through the bladder and urethra. The wound in the vesicovaginal wall is now ready to be sewed.

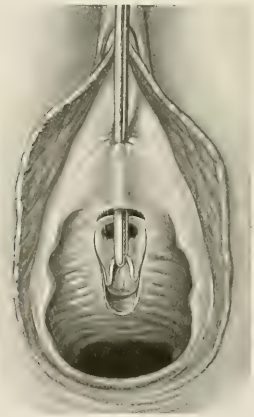


FIG. 1760.—CONSTRUCTION OF NEW URETHRA

Operation similar to that done for hypospadias. The flap of vaginal wall is drawn through the new canal.

great the same flap-splitting operation may be made to embrace it also. If the absence of urethral wall is great, the defect may be closed by turning in a flap of vaginal wall so that the mucous membrane is employed to line the urethra.

For the restoration of the urethra after sloughing, excision, or congenital absence of the same, an operation similar to that for hypospadias may be done. A urethral canal is made by placing a short transverse incision at the site of the new external meatus and another just anterior to the opening into the bladder, and connecting these by blunt dissection under the mucous membrane. A flap is then dissected from the vaginal wall of such a size and shape as to make a mucous lining for the new urethra. Its base includes the bladder opening. The mucous membrane flap is sutured to make a tube; forceps are passed from before backward through the tunnel and caused to grasp this mucous membrane tube and draw it through the tunnel. A catheter is passed through it to the bladder; and the new tube is sutured to the meatus (Fig. 1760). Flaps from the labia may be used instead of the vagina.

In the *cases of large fistulæ* the flap-splitting operation, in which the dissection is made between the bladder and vaginal walls, is employed. Here the dissection is carried on until mobilization of the bladder is sufficient for closure of the opening. The dissection must usually be carried up between the uterus and bladder as far as the peritoneum, as well as laterally. If necessary the peritoneum may be opened in order to permit the posterior wall of the bladder to be brought down. This permits of great mobility of the bladder wall. It is immaterial what direction the line of suture takes; the important thing being that the tissue be drawn from the direction of the least resistance, commonly the bladder is best closed by a transverse suture. It is of advantage if the vaginal and bladder sutures do not lie in the same direction. Often the uterus may be used to help fill the gap, and the bladder and vagina may be sutured to the anterior lip of the cervix. A cervical flap may be made by a transverse incision across the anterior fornix. If there is not enough vaginal tissue to cover the bladder suture, the wound may be dressed and treated as a granulating surface after the bladder has been sewed

In cases in which *high fistulæ* cannot easily be exposed the operation may be done through the abdomen, an incision being made in the peritoneum between the bladder and uterus. In such cases the bladder should be sutured in two layers, drainage through the anterior fornix of the vagina should be provided, and the peritoneum should be closed.

In cases of *small fistulæ* there may be much scar tissue, and failure is invited unless extraordinary care is taken to secure broad apposition.

In all operations there are certain *precautions to be observed*. A ureter should not be embraced in the sutures. When the opening is near a ureteral orifice the ureter should be dissected free so that the bladder sutures fall external to it. The mucous membrane of the bladder should not be incised beyond the margin of the bladder opening, as concealed bleeding into the bladder may take place.

The *after-treatment* is important. A self-retaining catheter should be fixed in the bladder. It should be left in for from four to eight days, depending upon how well it is tolerated. It is desirable that the bowels should not move for three or four days. Irritability of the bladder may be controlled by daily irrigation of the bladder with warm boric acid solution. The catheter should not be left in if it produces much irritation or discomfort. It should be watched carefully to see that it does not become clogged. If continuous drainage is dispensed with before the eighth day, the urine should be drawn

off with a catheter every four hours. By the eighth or tenth day the patient may be allowed to urinate.

Rectal Drainage of the Urinary Bladder.—There are desperate cases of vesicovaginal fistula which cannot be cured by any of the above procedures, because of destruction of the vesicle sphincter, or because of fixation of the vesicovaginal septum by scar tissue, or because of absence of the septum following operation for neoplasm. Because of repeated failures of attempts at repair some other expedient must be resorted to. Rather than leave a woman in the deplorable state of suffering constant dribbling of urine, the urine should be caused to empty into the rectum and the other urinary outlets closed. In many animals the urinary excretion passes into the rectum and is voided with the feces. The operation of implantation of the ureters into the rectum is a well-established procedure. This operation succeeds if the base of the bladder, with the ureteral openings, is transplanted into the rectum.

The operation which may be considered in *incurable cases of vesicovaginal fistula* consists in substituting the rectal for the vesical sphincter. The operation consists in providing a large opening between the bladder and vagina, if the opening is not large; a rectovaginal fistula is created; and the entrance of the vagina closed. The vesicovaginal opening should be made so large that it cannot close by scar contraction.

The artificial vesicorectal fistula should also be of large size. It should be longitudinal, in the median line, and large enough to admit two fingers. The mucous membranes of the rectum and vagina should be sewed together with chromicized catgut. It is not necessary to attempt the construction of a special valve to prevent the passage of feces into the vagina because a natural valve is formed. This opening should be made just above the internal sphincter muscle.

The vagina should be closed by denuding the introitus and sewing it together with a double layer of sutures of chromicized catgut (colpocleisis). The outer layer of sutures may be of silk or silkworm-gut. The operation may be done in one or two stages. At the first operation the two fistulæ are made, the vagina being closed at the second operation. A one-stage operation can usually be done unless the local congestion and irritation are very great. Some surgeons have placed a tube in the rectum, which passes through both fistulæ and provides urinary drainage for the first two days. This is probably not necessary.

The operation of colpocleisis is apt often to fail in some respect. Some leakage may occur. The small urinary fistula which results may be expected to close spontaneously, or with a few applications of silver nitrate.

R. Peterson (Surg., Gyn. and Obst., October, 1917) collected 40 reports of this operation and added a successful case of his own. The results are most gratifying. Natural sexual intercourse is prevented, but the patients are able to keep dry and clean. The urine does not give rise to rectal irritation, nor to diarrhea. Usually the stools are normal, though they may be softer than before. The patients have one or more formed stools each day. The urine is passed at intervals varying from two to eight hours. Urination takes place independently of defecation. Most women menstruate through the rectum after the operation. This continues without apparent inconvenience. In some cases menstruation has ceased after the operation. There seems to be no tendency to uterine infection. Ascending infection passing up the ureters has not occurred in these cases.

Vesico-uterine Fistula.—Defects between the bladder and uterus may be reached through a transverse incision in the anterior fornix of the vagina

provided the introitus vaginæ is capable of wide dilatation. By carrying the dissection upward the bladder may be liberated and brought down so that the fistulous opening is accessible. The dissection between bladder and uterus may be carried up to the peritoneum. If good access cannot be gained, the operation should be done through the abdomen. In the latter case a transverse incision is made through the peritoneum in the sulcus between uterus and bladder. The opening in the bladder is exposed and closed with two layers of sutures—the first embracing all the coats of the bladder excepting the mucosa, and the second burying the first suture by catching the outer coats and the surrounding connective tissue. The anterior fornix of the vagina should be opened and a small drain brought out through it. The cervical canal should have been dilated. The opening in the uterus should be freshened and closed. Before operating the bladder should have been washed out with boric acid solution and emptied of fluid.

Hysterectomy may be done through the vagina in order to make more room for the vesical operation, if it is not deemed wise to perform a transabdominal operation. In the case of a much-depleted woman, past the menopause, suffering with an old vesico-uterine fistula, complicated by diabetes of a serious degree, I performed vaginal hysterectomy and closed the opening in the bladder, with the result that the fistula was permanently healed and the general condition of the patient much improved.

A method of approach from below which other surgeons have practised with success has consisted in splitting the cervix anteriorly in the middle line as far up as the fistula. Scar tissue is then removed and the wound closed.

Ureterovesicovaginal Fistula.—The ureter, participating in a vesicovaginal fistula, must be preserved from injury. The lower end of the ureter may be circumscribed by an incision and liberated; the fistula is then freshened and sutured in such a way that the ureteral opening is turned back into the bladder.

Another method consists in splitting up the ureter so as to enlarge its opening, or, more properly speaking, shorten the ureteral canal. This should be done as a preliminary operation. To prevent the wound from healing together, it may be touched with silver nitrate or the cautery, or the edges may be crushed with a clamp. This places the ureteral orifice higher up and permits closure of the vesicovaginal fistula without danger of obstructing the ureter.

E. C. Dudley placed a long narrow clamp on the ureter, one blade entering the ureteral canal the other being in the bladder. This clamp is closed, and by its pressure in a few days causes a necrosis through the anterior wall of the ureter.

Ureterovaginal Fistula.—This condition need not be treated by dissecting the ureter out of the scar tissue and implanting it anew into the bladder, as has been practised. It is simpler to incise the vesicovaginal septum from the fistula downward, and thus, by performing colpocystotomy, convert the lesion into a ureterovesicovaginal fistula. This gives access to the ureteral opening which may then be accorded the consideration necessary for its cure (see above).

Ureterovaginal fistula following hysterectomy has been treated by nephrectomy. This effectively cures the fistula, but is an unnecessarily serious and indirect procedure for a condition which is amenable to more direct methods. The ureteral opening may be inverted into the bladder. A curved incision is made in the vault of the vagina posterior to the scar tissue through which the ureter opens. The mucous membrane is dissected back as a flap, leaving a denuded surface. Anterior to the scar a second curved

incision is made so that the two form an ellipse. Through this incision the septum between bladder and vagina is incised transversely. The anterior

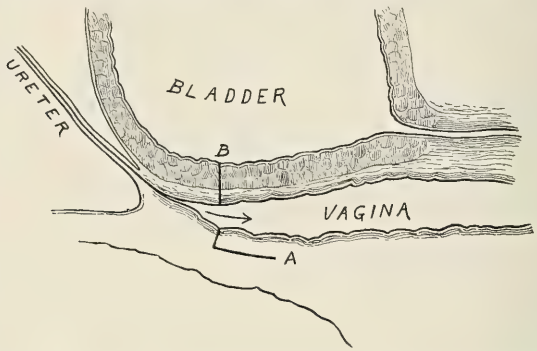


FIG. 1761.—CLOSURE OF URETEROVAGINAL FISTULA FOLLOWING HYSTERECTOMY.

The vagina is denuded posteriorly below the ureteral orifice by turning down a flap (*A*). The vesicovaginal septum is incised (*B*) anterior to the ureteral opening in the vaginal scar.

edge of the bladder wound is then drawn down into the vagina and sutured to the denuded surface posterior to the scar. This causes the scar and the ureteral orifice to lie inside of the bladder. The vaginal opening is then

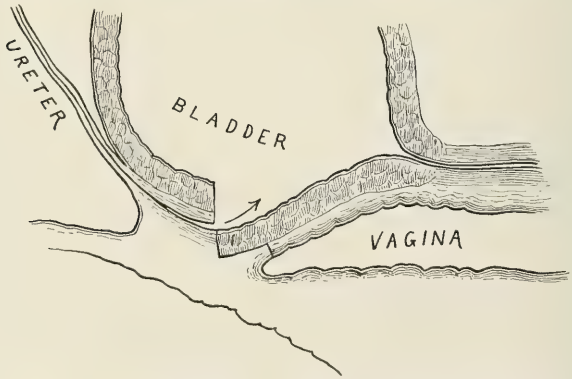


FIG. 1762.—CLOSURE OF URETEROVAGINAL FISTULA FOLLOWING HYSTERECTOMY.

The anterior lip of the bladder wound is drawn down and sewed to the denuded area posterior to the ureteral opening. The flap on the posterior vaginal wall is sewed to the anterior vaginal wall.

closed (Figs. 1761 and 1762). A catheter is fixed in the urethra for permanent drainage as for vesicovaginal fistula (*q.v.*).

Rectovaginal Fistula.—The treatment is similar to that of vesicovaginal fistula. After the patient is anesthetized, the sphincter ani should be stretched until paralyzed (see Wounds of Rectum, page 60; and Dilatation of Sphincter, page 60). The lining of the fistula should be excised through the vagina. The resulting wound should be larger on the vaginal side. The vagina should be dissected from the rectum for a short distance around the fistula. The rectum should then be sutured separately, the sutures not embracing the rectal mucosa. A second layer of sutures should close the vaginal wound. Chromic catgut is used. The after-treatment should be the same as that for wounds of the rectum.

Vaginitis.—*Acute simple vaginitis* requires treatment similar to that of vulvitis (page 327). Rest in bed for one or two weeks should be required, even in mild cases. The bowels should be well moved. A cleansing douche should be given 2 or 3 times a day; if the discharge is profuse it may be given oftener. At night a tampon saturated with a solution of silver nitrate (1:500), a 2 per cent. solution of protargol, or 25 per cent. solution of argyrol should be placed in the vagina. If this causes pain a weaker solution should be used. If violently acute inflammation with much edema is present this should be omitted, and the douches given more frequently. For pain, hot sitz-baths, or hot compresses to the vulva, are to be recommended. These may be used as often as necessary. Douches of thymol (1:1000) are of value as sedatives. Warm injections of creolin or lysol (1 per cent.) often give comfort.

After the pain has ceased and the discharge diminished the patient may be allowed up. The frequency of the douches is made less. As the acute symptoms subside douches of chlorazene, chloramin, iodin solution, bichlorid of mercury (1:5000), potassium permanganat (1:2000), or boracic acid solution may be used. The silver tampon is continued at night. The formation of an *abscess of the vaginal wall* calls for free incision through the vagina, irrigation, and packing the cavity with gauze.

Chronic simple vaginitis is treated twice daily by a vaginal douche of one of the above-mentioned antiseptic solutions. Silver tampons are used at night. After a few days of this treatment astringent antiseptic injections are employed alone instead. These are used night and morning after the vagina has been washed out with sterile water. The astringent douche may consist of boracic acid (4 parts), zinc sulphate (1 part), and water (100 parts). Solutions of tannic acid (2 per cent.) alum (2 per cent.), lead acetate (1 per cent.), or ichthyol (2 per cent.) are useful. Ichthyol is of service when used in wool tampons with glycerin (glycerin 9 parts, ichthyol 1 part).

In some cases astringent powders act better than solutions. For this purpose the vagina should be washed out, a speculum introduced and the mucous membrane sponged dry. The above astringents may be applied in powder form, mixed with some bland substance such as oxid of zinc. Subgallate of bismuth mixed with an equal amount of stearate of zinc is most effective.

Erosions should be touched with silver nitrate and covered with a bland powder. If cure does not progress satisfactorily the case should be treated by painting the whole vaginal mucous membrane every second or third day with 2 to 5 per cent. silver nitrate solution.

Tincture of iodin is of service in some obstinate cases. After each treatment the vagina should be packed with gauze, and the treatment continued until desquamation of the vaginal epithelium takes place. Then astringents should be employed for a few days.

It should be borne in mind that by no means is all *vulvovaginitis in children*

gonorrheal in character. The surgeon should not be deceived by the presence of a diplococcus and treat all such cases for gonorrhea. Most cases of vulvovaginitis in children are clinically milder than gonorrhea, and yield to milder measures of treatment. When a child has true gonorrhea the disease is severe, even more severe than in the adult, and requires intensive antigonorrheal treatment.

In *senile vaginitis* no treatment is required if there is nothing more than a slight discharge. If the discharge is annoying or ulcerations are present a copious douche of warm water should be given daily. If this alone does not effect a cure the douche should be followed by the introduction into the vagina of a wool tampon soaked with a mixture of ichthyol (1 part) and glycerin (9 parts). Or boroglycerid may be used instead. A tampon soaked with vinegar has proved effective. Ulcerated areas should be treated with silver nitrate. Old adhesions require no treatment unless they interfere with the exit of discharges and then they should be divided. Recent adhesions may be broken with the finger, kept apart by tampons, and the raw surfaces treated as ulcers.

Granular vaginitis, following simple or gonorrheal inflammation, is treated the same as simple acute vaginitis. If antiseptic douches fail to cure, each douche should be followed by drying out the vagina and the introduction of a tampon covered with a mild astringent powder such as bismuth subgallate and stearate of zinc. Local treatment with silver nitrate or copper sulphate may sometimes be necessary for the cure of granulations.

Gonorrheal vaginitis (see page 284).

Tumors of the Vagina.—*Cysts* should be removed if large enough to produce symptoms. A cyst which is come upon during some other operation may be removed because of the probability of later trouble arising from it (see Cysts, Vol. I, page 325).

Benign tumors should be treated the same as cysts; operated upon if they cause symptoms; and removed at operation for some other condition if they cause no symptoms. *Polyps* of the vagina should be removed by cutting out an elliptic segment of vaginal wall bearing the polyp, and closing the wound. In order to make room, removal of the tumor by ligating the pedicle may be done. Very large polyps, filling the vagina, may require for their removal enlargement of the vulva by making a median perineal incision. The growth may then be delivered with toothed forceps. After its removal the perineal wound should be sutured.

Carcinoma of the vagina, when primary, should be removed by the widest excision possible. The prognosis even then is very bad. No cures have been reported. Recurrences have been reported after extirpation of the vagina, uterus and appendages, rectum and sigmoid, and bladder. It may be laid down as a rule that all of the vagina excepting the opposite wall should be removed. No part of the vagina or vulva nearer than 2.5 cm. (1 inch) to the growth should be left. The uterus should be removed. In carcinoma of the anterior wall the lower half of the bladder should be excised. In carcinoma of the posterior wall the rectum should be removed. Adjacent connective tissue should be dissected out as far as the pelvic wall. The only hope for these cases is discovery of the disease and extirpation before it gives rise to symptoms.

Carcinoma of the vagina which has extended from an adjacent organ should be treated upon the principles laid down for the primary disease and its extension. Epithelioma extending to the vagina from the cervix, if early and widely excised, need not be regarded as hopeless.

In primary *chorio-epithelioma* of the vagina, excision of the growth with

a fair amount of healthy vaginal tissue offers good hope of cure. In cases secondary to uterine involvement removal of the disease-bearing organs offers less hope than in primary disease of the vagina.

Vaginismus (see page 329).

Foreign Bodies in the Vagina.—Simple mechanical skill is required for the removal of foreign bodies. Usually they may be picked out with forceps. A finger in the rectum is often of service. Sharp or pointed bodies should be handled with much care to avoid wounding the vagina. In some cases the object may be cut in two or crushed with advantage. A general anesthetic is desirable if the operation is to be painful or difficult. In old cases bands of adhesions may have to be divided. Fine particles such as sand may be washed out. Fragments of broken glass may be captured by using plastic cement, putty, clay, chewing-gum, or plasticine. Resulting vaginitis should be treated with irrigations of boric acid solution.

Malformations of the Vagina.—*Persistent cloaca*, whereby the rectovaginal septum and anus are absent, is to be treated by dissecting free the rectum, making an anal opening through the fibers of the levator ani muscle, bringing down the rectum and sewing it to the skin. The edges of the vaginal defect are freshened and sutured together.

Double vagina, due to a septum, in its several forms, requires no treatment if the vaginal functions are not interfered with. If they are, the septum should be divided and the vagina packed with gauze to prevent recoalescence while healing takes place.

Double vagina and uterus, as well as double vagina may be treated by removal of the septum. A long, straight, pedicle clamp is placed on the septum posteriorly and another anteriorly, and the septum divided with scissors between them. Long retractors may then be introduced into the enlarged vagina and the cervix exposed. The two uterine canals may then be dilated and their direction determined. A long curved pedicle clamp is then inserted, one blade into each uterine canal, and closed down upon the uterine septum. The handles of the three clamps are then packed about with gauze to protect the vagina and vulva and to prevent displacement of the clamps. They may be removed at the end of forty-eight hours. The lines of compression will come away as sloughs in due time.

Atresia of the vagina should be treated by dissecting through the obstruction. By introducing a sound in the bladder and a finger in the rectum, as guides, wounding these viscera may be avoided. If the remaining wound surface is small the vagina need only be packed with gauze until it is covered with epithelium. If the surfaces are large they should be covered by plastic sliding of the vaginal wall.

Absence of vagina may be treated by making an artificial vagina. This is necessary only when there is a uterus which produces discharges which are retained. When there is absence of uterus no operation is necessary. In cases in which a vagina is demanded by the patient for purposes of sexual intercourse the surgeon may, if he wishes, lend his talent to this service. Hysterectomy has been performed in cases with obstructed discharges, but in such cases the creation of a vagina is by far the more desirable operation. In cases producing menstrual blood, operation is necessary to prevent rupture of the retained secretions through the peritoneum or into adjacent viscera. In cases with functionally active uterus and ovaries, the indications are to make a vagina, irrespective of the present sexual demands of the patient.

For the *formation of a new vagina* many operations have been devised. The simple operation consists in making a vertical median incision through the vulvar skin and thence a transverse dissection between the bladder and

rectum up to the collection of menstrual blood or to the uterus. The labia minora are then dissected free for a short distance and pressed into the vagina, sewed in place and the vagina held open by a plug or tampon. In making the dissection between bladder and rectum a finger in the latter and a sound in the former, acting as guides, will prevent wounding them.

A more effective result is secured by making a big opening throughout the rectovesical space, extending well up to the uterus. The labia minora are then dissected up with their underlying connective tissue and the two layers of each dissected apart so that they consist of one layer each. These elongated strips of mucous membrane are then carried up and sutured at

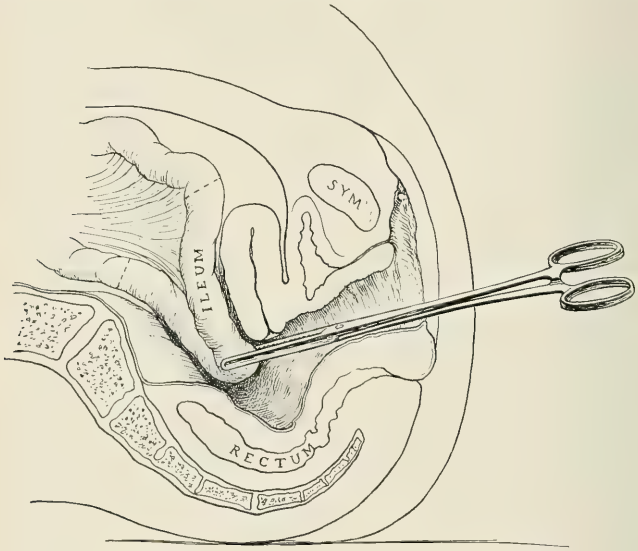


FIG. 1763.—CONSTRUCTION OF ARTIFICIAL VAGINA FROM INTESTINE.

A vaginal passage is formed by dissection from the vulva to the retroperitoneal pouch. A loop of bowel is grasped and the abdominal operation from above is entered upon. The dotted lines indicate the place of resection of the bowel.

the sides of the cervix. They should also be caught by a few interrupted sutures to the connective tissue upon which they lie. The operation should be done with the utmost aseptic care. The new vagina should be packed with gauze enough to keep it dilated and the flaps pressed in place but not with pressure that may interfere with their nourishment. Between the flaps and the gauze should be interposed some nonadhesive substance such as silver foil, to prevent damage to the flaps when the gauze is removed. The gauze should remain in for five days and be kept dry. This operation places mucous membrane upon the sides and leaves a raw strip anteriorly and posteriorly to cover by extension. The resulting vagina may be ex-

pected to contract to such a degree as to be ineffective for purposes of copulation unless kept dilated by artificial means.

If the labia minora are not adequate for the fabrication of large flaps the dissection may include the labia majora also.

The making of an *artificial vagina by intestinal transplantation* was described by J. F. Baldwin (Annals of Surgery, September, 1904). After dissecting up through the vesicorectal septum as far as the peritoneum of the prerectal cul-de-sac, a pair of long forceps are placed in the wound and packed about with gauze. The patient is then taken down from the perineal position, and the abdomen opened above the pubes. A loop of the sigmoid

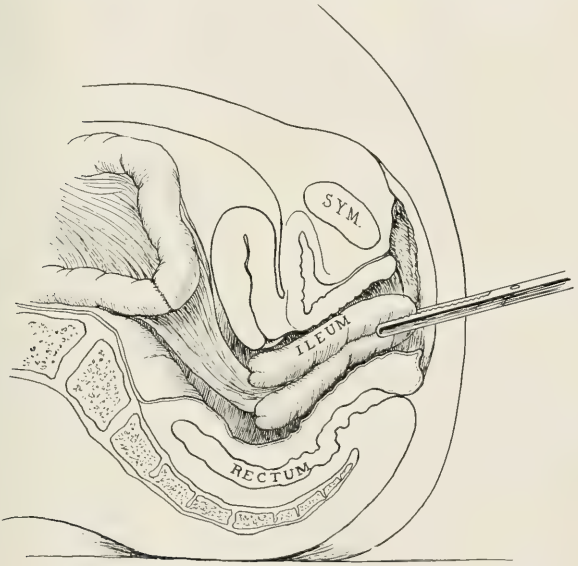


FIG. 1764.—CONSTRUCTION OF ARTIFICIAL VAGINA.
The loop of intestine has been resected and is drawn down into the passage between the bladder and rectum. The bowel is united.

or the lower end of the ileum is drawn up and the surgeon satisfied that its mesentery is of sufficient length for the purpose. The contents of about 30 cm. (12 inches) are pressed out, the bowel clamped and that length resected (Fig. 1763). The continuity of the intestinal canal is reëstablished by making an anastomosis. The free ends of the resected segment are inverted and closed by sutures. The peritoneum of the cul-de-sac is then incised. The long forceps are caused to grasp the resected segment exactly in its middle and draw it down to the introitus. Its mesentery should be preserved from injury. The two free ends should be caught by sutures to the connective tissue and fascia below the peritoneum. The peritoneum should then be sutured over the resected segment and around its mesentery. The ab-

domen is closed. The patient is again placed in the perineal position, the bowel opened where it had been grasped by the forceps, the contents wiped out, and the opening sutured to the skin at the introitus vulvæ (Fig. 1764).

This leaves a vagina having a septum. The two sections are packed with gauze to keep them dilated and their peritoneal surfaces pressed against the wound to which they become adherent. At a later operation the septum may be divided, and a capacious vagina produced. The patient should be warned against the use of poisonous douches because of the active absorbing power of the intestinal mucous membrane.

W. L. Wallace (Buffalo Med. Jour., February, 1911) advised drawing down the opened ends of the resected segment and suturing them to the vulva, thus leaving a smooth fundus to the vagina, obviating inverting the free ends, and using less bowel.

P. Strassmann (Zeitschr. f. Geburtsh. u. Gynæk., vol. 76, No. 1, 1914) operated without opening the abdomen, using a segment of rectum to make a new vagina. The isolated rectum is divided transversely about 2.5 or 3 cm. (1 inch) above the anus. The end of the divided rectum is brought forward and sutured to the vulva. The rectum is then amputated high enough to give a vagina of the desired length. If there is a uterus it is sutured into the upper end of this segment; if there is none the upper end is closed as a blind pouch. The proximal stump of bowel is then drawn down and sutured at the anus. All of this dissection may be done through a U-shaped incision, the two arms of which lie on either side of the anus and the convexity directed forward.

A median operation whereby the rectum is converted into vagina is by the following method: The vulvar orifice or the anterior stump of the vagina is freshened and prepared to have the new vaginal tube sutured to it. The sphincter ani is then dilated and the anus is circumscribed by an incision, through which the rectum is dissected free from the sphincter. The sphincter is left unharmed.

Forceps carrying a tampon are inserted in the rectum. A median incision is then made. It is 10 cm. (4 inches) long, begins 5 cm. (2 inches) posterior to the anus, and exposes the coccyx. The coccyx is removed. The rectum is then exposed in the wound and isolated for a distance of 12 cm. ($4\frac{3}{4}$ inches) above the anus. The rectum is then drawn down by ligating and dividing connective-tissue bundles which interfere. The peritoneum is opened if necessary to draw down more bowel. The rectum is then divided at a point which will permit the proximal stump to be drawn down and sutured at the anus. The upper end of the lower segment is closed by catgut sutures. The upper segment is tamponed. The anal end of the rectum is then displaced forward into a pocket which is prepared for it and sewed to the vulva or to the vaginal stump. The proximal bowel is drawn down through the sphincter ani and sewed to the skin. If a uterus is present, it is connected to the upper end of the new vaginal tube.

THE UTERUS

Wounds of the Uterus.—*Penetrating wounds* require treatment upon the same general principles as penetrating wounds of the abdomen (Vol. II, page 535). A *punctured wound*, made by a curet or other instrument in an aseptic operation requires only that nothing further be done that might make matters worse. The condition is much more grave if occurring in the presence of infection. In the latter case the best judgment must be used. When the uterus is torn through or punctured in removing septic placenta, it may suf-

fice to put in a copious gauze drain which should be lead out through the vagina. If infection of the uterine wall is known to exist, vaginal hysterectomy often becomes the safest procedure. Hysterectomy should be the operation of choice when there is doubt.

In cases in which intestine has entered the uterus in an uninfected case, the bowel should be pressed back, the cervix tamponed, the abdomen opened above the pubes, and the rent in the uterus sutured. *Suture of the uterus* is best done with chromicized catgut, penetrating all layers except the mucous membrane. A single layer of sutures suffices. They should be interrupted, and placed well back from the wounded edges. A puncture does not require suture, but a wound longer than 3 mm. ($\frac{1}{8}$ inch) should be sewed. Large ragged wounds should be closed with interrupted sutures.

The treatment of replaced bowel should be the same as in wounds of the abdomen. If infection is believed to be present, drainage may be used. If no infection is present, drainage may be dispensed with.

In *puncture of the pregnant uterus*, such as has occurred from within the abdomen when the pregnancy has been mistaken for a cystic tumor, one of three courses of treatment usually is to be followed: (1) If the puncture involves the amniotic sac, and amniotic fluid escapes, Cesarean section is the operation of choice. (2) If the puncture involves only the uterine wall, no further treatment, excepting quiet for the patient, is indicated. A wound that is more than a puncture should be sutured. (3) In the case of punctures of the uterus which have been followed by abortion without complications, no further treatment is necessary.

Hysterectomy may sometimes be called for in ragged destructive wounds. Intra-uterine irrigation or injections should not be made in the presence of an unclosed wound.

In *rupture of the uterus* in pregnancy, immediate action is called for. In cases in which the pelvic canal is too small for the head, rupture during parturition may be prevented by delaying a too rapid labor by means of sedatives, or by performing Cesarean section at the end of gestation. After rupture has occurred, the treatment varies with the nature of the injury. In all cases rapid removal of the fetus is to be done. In the case of a small extraperitoneal rupture, low down, without escape of the child, rapid delivery should be done; after dilating the cervix, and extracting the child, contraction of the uterus should be secured by styptic irrigation and packing the uterine cavity with gauze. In the case of larger extraperitoneal tears with serious bleeding, after extraction of the child, the wound should be exposed either through the cervix or by incising the broad ligament through the abdomen, and the wound closed by sutures. Bleeding into the broad ligament may be severe, and only controlled by cleaning out the clots and sewing the uterus. It sometimes happens that the partial escape of the child through the tear stops the bleeding, but as soon as the child is extracted, bleeding becomes active and requires rapid exposure and suture of the wound.

When rupture through the peritoneum takes place the abdomen should be opened at once if the head or a large part of the body has escaped into the abdomen and removal of the child from below is very difficult. In such an event the child and placenta should be delivered through the tear and the uterus closed as in Cesarean section (*q.v.*). Rapid operation is also required if the child has escaped wholly into the abdomen. In rupture through the peritoneum without escape of the child, after delivery it is possible that healing of the wound may follow the introduction of a drain through the cervix up to the fundus; but a safer treatment consists in opening the abdomen and sewing up the wound. Ragged edges should be trimmed off. Two

layers of sutures may be used. If it is believed that the uterus is infected seriously hysterectomy should be done.

Coils of intestine presenting at the cervix after delivery require that the abdomen be opened above the pubes, the intestine drawn out and cleansed, and the wound of the uterus sewed.

Uterine hemorrhage requires that treatment be applied to the cause of the bleeding. The hemorrhage of pregnancy, endometritis, mucous degeneration, cancer, and benign tumor all require treatment of the cause. They are discussed under their respective heads (see also Hemorrhage, Vol. I, page 334).

Irrespective of the cause, it may be mentioned that bleeding may be checked by injections of phenol, by hot irrigations of the interior of the uterus, by styptic solutions such as vinegar or weak acetic acid, by packing the uterus with gauze, by compression of the abdominal aorta, by clamping the uterine arteries, or by closing the external os by sewing the cervix.

Chronic hemorrhage is the most common form of bleeding from the uterus. The *x*-ray is useful in certain cases of fibroid tumor. The *x*-ray may be applied to the ovaries to destroy their function and thus induce premature menopause. Radiation applied to the uterus stops the bleeding in most cases. A séance of one hour each is given on six successive days over six different fields on the suprapubic region. Each field should be about 5 cm. (2 inches) square.

Radium is used in the uterus for the same purpose. Only the gamma rays are employed. The alpha and beta rays are filtered out by a lead covering 2 mm. thick. A rubber filter 1 mm. thick absorbs the secondary rays. About 1000 milligram-hours of radium in the uterine canal suffice to cause amenorrhea. The capsule is aseptically introduced, and for its removal a thread is attached. Before employing these radiant methods cancer should be excluded. Radium is capable of producing complete amenorrhea at any age.

Zinc chlorid may be used if carefully applied. The uterine canal is dried with gauze, and a narrow strip of gauze is passed to the fundus and 5 or 6 drops of a 10 per cent. solution injected into the gauze at the fundus. More gauze is then packed in and a few more drops injected with an intrauterine syringe into the gauze. The rest of the canal is then packed with the dry gauze, the end of which hangs from the cervix and has a string tied to it for removal. Not more than 20 drops of the 10 per cent. solution should be used. The gauze is removed in three days. This treatment may be applied every four weeks until a cure is secured. The solution should not come in contact with the cervix lest it cause stricture.

Laceration of the Cervix.—*Primary trachelorrhaphy* (suture of the cervix), for lacerations following parturition, is not done in the presence of edema and distortion of the parts and danger of interfering with uterine drainage. When the surgeon can overcome these conditions, immediately after delivery, sutures may be applied. The sutures should be introduced as for later trachelorrhaphy (*q.v.*) excepting that they should be placed further away from the cervical canal. I have often sutured a widely lacerated cervix immediately after delivery with most satisfactory results. The operation should be done only in cases with wide laceration, and allowance should be made for the narrowing of the os which is going to follow subsidence of edema and contraction of the uterus. In cases of moderate laceration it is better to defer operation until after the puerperium and the healing of all wounds.

Intermediate trachelorrhaphy is done four or six weeks after confinement, especially in primipara or women without previous laceration, and in lacera-

tions which cannot be regarded as inconsiderable. Slight lacerations need no operation. The more pronounced lacerations may be sutured at this stage and all of the inconveniences of primary suture obviated and the dangers of old laceration prevented. In women who are not nervous, no anesthetic is required. The anterior and posterior lips of the cervix are caught with a tenaculum in line with the direction of the canal. The raw surface of the laceration is scraped with a sharp knife; the wound is closed with interrupted sutures of chromic catgut; and the patient allowed to go about as usual. Coitus should not be indulged in for three weeks.

Later trachelorrhaphy is indicated in cases in which there is a laceration, the surfaces of which show granulations, chronically inflamed mucous mem-

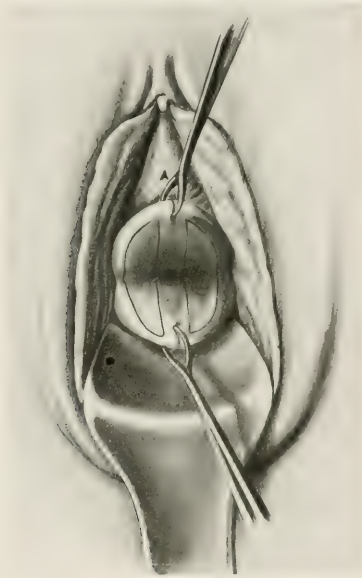


FIG. 1765.—TRACHELORRHAPHY (FIRST STAGE).
Cervix held by tenacula. Lines of incision shown.

brane, edema, subinvolution or cysts of the cervix. Inasmuch as one or the other or all of these conditions may be present in old lacerations, and because of the great proneness to the development of cancer in such crevices, operation is imperatively called for in most lacerations of the cervix in women past the child-bearing age. In the case of a young woman who is yet to bear more children, it is not worth while operating because the work will be undone at the next labor; under such circumstances the operation is to be done only if the laceration is giving rise to symptoms. Operation not only is capable of curing the cervical discharge and the chronic endometritis which it engenders but of saving the woman from the development of cancer later

in life. Trachelorrhaphy should not be done in the presence of uterine infection or salpingitis. When operation is not called for, erosions and cervical catarrh may be treated by local applications.

The patient should be prepared for vaginal operation and placed in the elevated pelvic position with thighs and legs flexed. The vagina should be cleansed with soap, a sponge on a long holder, and sterile running water; this should be followed by irrigation with a mild antiseptic solution to wash out the soap, as for perineorrhaphy (see page 335) and the covering of the parts should be the same. A vaginal retractor, preferably of the weighted variety, should be introduced and the cervix exposed. Usually the presence of chronic endometritis demands attention. This should be treated first.

In the case of a bilateral tear a double tenaculum grasps each lip of the torn cervix exactly in the median line. The two lips are held apart by the

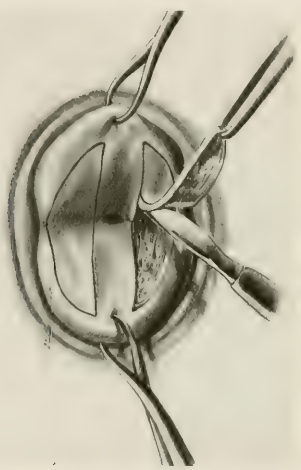


FIG. 1766.—TRACHELORRHAPHY (SECOND STAGE).
Dissection in progress. Note that dissection is made from below upward.

assistants. Each angle of the laceration on either side of the cervical canal is then excised as follows: An incision with a small scalpel is made on the posterior lip, first on one side and then on the other side of the median line, leaving a strip of mucous membrane between them about 8 mm. (⅓ inch) wide. This represents the posterior half of the lining of the restored cervical canal. These two incisions should be continued in the same direction upon the anterior lip, outlining the mucous membrane for the anterior half of the reconstructed canal. From the lower ends of each of these an incision is carried around the margin of the tear enclosing an area to be denuded on either side (Fig. 1765). These areas should be outlined, one at a time; and then dissected out, the posterior ones first. The dissection of these two areas should extend well up into the angles of the old wound with the view of removing the old scar tissue. By dissecting the two posterior surfaces

first, the field of operation is not obscured by blood running down from the anterior surfaces (Fig. 1766). Ligation of vessels is rarely necessary. If a vessel spurts it may be controlled by immediately introducing one of the sutures.

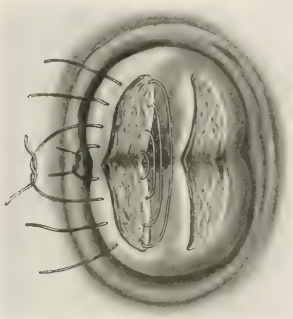


FIG. 1767.—TRACHELORRHAPHY (THIRD STAGE).
The laceration has been denuded on either side. A strip of mucous membrane is left in the middle to form the cervical canal. The sutures have been placed on one side.

For suture material chromicized catgut is to be preferred. From three to five sutures on either side usually suffice. They are placed about 3 mm. (⅛ inch) apart. A needle, representing in its curve about a third of a circle, is best. The first suture is placed at the upper angle. The needle passes in

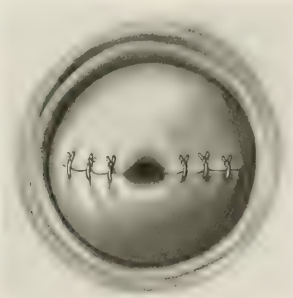


FIG. 1768.—TRACHELORRHAPHY (FOURTH STAGE).
Showing immediate result of operation.

through the mucous membrane of the vaginal side and emerges in the wound on the same lip close to the median strip of mucous membrane; thence in the corresponding wound surface of the opposite lip, to emerge through the mucous membrane of the vaginal surface (Fig. 1767). By holding the two tenacula evenly, the sutures on each side should be placed so that the wound closes

symmetrically. Before tying the sutures, blood should be cleaned out by irrigation with saline solution. Clots should not be left in the wound. If curettage has been done the uterine cavity should be washed out to remove

FIG. 1769.—UNILATERAL TRACHELORRHAPHY (FIRST STAGE).
Closure of unilateral laceration by a continuous suture. Showing deep continuous suture. (Method of W. L. Wallace.)

blood. The tenacula should be removed, and the sutures tied from above downward. The sutures should be tied snugly with firm knots at one side of the wound (Fig. 1768).

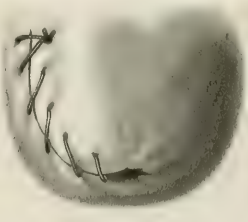


FIG. 1770.—UNILATERAL TRACHELORRHAPHY (SECOND STAGE).
Closure of unilateral laceration by a continuous suture. The buried suture, having reached the lower end of the wound, is continued back again as a continuous superficial suture and tied to the beginning at the upper end of the wound. Method of W. L. Wallace.

A continuous layer suture is used by some surgeons in closing the cervical wound, with the view of securing flat apposition of the surfaces (Figs. 1769 and 1770). This method is described by W. L. Wallace (Jour. Am. Med. Assoc., Apr. 9, 1910).

In the case of unilateral laceration, the operation is done on only one side. Stellate or multiple lacerations may be treated by bilateral trachelorrhaphy, but if the lacerations are deep, amputation of the cervix is

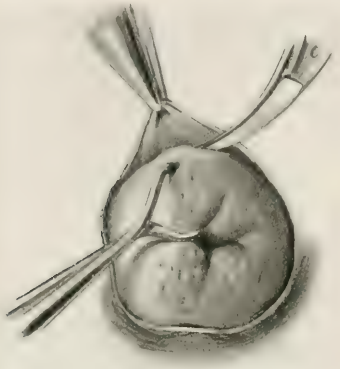


FIG. 1771.—CONICAL TRACHELOPLASTY (FIRST STAGE).
Mucous covering of cervix dissected free. Method of Sturmdorf.

best. In some cases partial amputation of one lip may be combined with trachelorrhaphy.

FIG. 1772.—CONICAL TRACHELOPLASTY (SECOND STAGE).
Cone of diseased cervix removed. Method of Sturmdorf.

In cases of stellate lacerations, granular cervicitis, and endocervicitis in which amputation of the cervix or trachelorrhaphy is indicated, a plastic removal of the diseased tissue may be done. *Conical trachelorplasty* is done

by incising the mucous membrane around the cervix just beyond the diseased area. The circular incision should be evenly made. The mucous membrane is dissected back, thus denuding the cervix (Fig. 1771). A cone of diseased cervical tissue is then removed from the cervix (Fig. 1772). The liberated

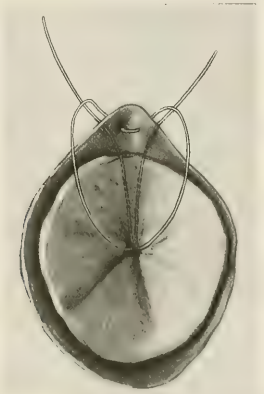


Fig. 1773.—Conical Tracheloplasty (Third Stage).
Transverse traction stitch for the anterior flap. Method of Sturmdorf.

mucous membrane is then sewed over the stump. For accomplishing this suture A. Sturmdorf (Surg., Gyn. and Obst., vol. xxii, January, 1916) devised a suture which draws the mucous membrane into the cervical canal (Figs. 1773 and 1774). An anterior and posterior suture are applied. If necessary accessory sutures may be used (Fig. 1775).

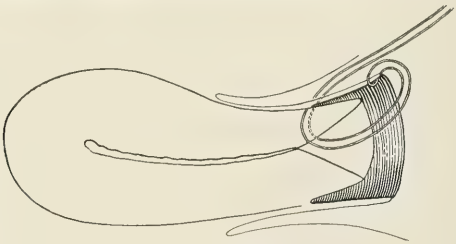


Fig. 1774.—Conical Tracheloplasty.
Diagram showing method of placing anterior suture. Method of Sturmdorf.

Inflammations of the Uterus.—*Cervicitis* when acute is treated the same as acute vaginitis. Chronic cervicitis, giving rise to *cervical catarrh*, should be treated by vaginal applications and by insuring free drainage. Tenacious mucus should be drawn out by suction or sponged away. A big wool tampon, soaked with boroglycerin, should be placed against the cervix, and the for-

nices packed with gauze saturated with the same. This should remain in for a day, and be followed by a douche. The treatment may be used every second or third day.

For *erosions* of the cervix, local application of tincture of iodin is to be recommended. It may be used in connection with the glycerin tampons. Astringent powders containing alum, zinc sulphate, or tannin are also employed. None of these strong substances should be applied to the mucosa of the cervical canal. Cysts and dilated follicles should be punctured and swabbed out with iodin.

In *ectropion* of the mucous membrane of the cervical canal, found in old lacerations, trachelorrhaphy is indicated; if the cervix is swollen and beset with dilated follicles, amputation is best.

Acute endometritis should be prevented by surgical cleanliness in all vaginal and uterine contacts. Cleanliness in the puerperium, prompt removal of infected products of labor, and clean sexual congress are essential in prophylaxis. The most important features of the active treatment consist in securing good drainage by patency of the cervical canal, rest in bed for the patient, and increasing the bodily resistance against the infection. Any gross infective material present in the uterus should be removed by irrigation, or by instrumental means, but care should be taken not to cause abrasion of the endometrium. For this latter purpose the dull curette is employed, or the surgeon's finger.

In *acute gonorrheal endometritis*, the patient should be kept quietly in bed. The treatment of the vulvovaginitis should be carried out. The patient should be kept in bed for at least a week after the temperature has become normal (see page 283).

FIG. 1775.—CONICAL TRACHELOPLASTY (FOURTH STAGE).

Showing result after both anterior and posterior sutures have been tied. Method of Sturmdorf.

Chronic endometritis, being due to the presence of bacteria of many kinds, to infections which have subsided or to trophic and circulatory disturbances (J. P. Warbasse, Researches in the Bacteriology of Chronic Endometritis, Am. Jour. of Med. Sciences, February, 1898), is amenable to treatments which vary with the etiologic conditions present. Personal hygiene should be improved; causative factors should be removed. Displacements should be corrected.

The application of tincture of iodin and phenol (equal parts) to the endometrium is often of service. Such treatments are carried out by passing a small tube up to the fundus and injecting the medication through it. The tube should be so small that the fluid easily escapes beside it. A packing of gauze around the cervix absorbs the medication as it flows out. Such treatment may be used once a week.

Prophylaxis is of the same importance as in the acute variety. Lacerations of the cervix, keeping up an endometritis, should be cured. Free drain-

age should be secured by a wide os uteri. Dilatation alone is often curative. If the disease does not subside after good drainage has been secured and cervicitis cured, then curettage is called for.

Leukorrhea, which is a symptom of cervicitis, endometritis and vaginal infection is relieved by curing the cause. Many of these cases are associated with a growth of bacteria in the vagina which aggravates the disease. Mucous discharge from the cervix acts as a culture medium. Hypertrophied glands must often be removed. If a specific infection can be identified, autogenous vaccines are useful.

Among the measures which have been applied directly for the relief of leukorrhea, treatment by the local application of sugar is worthy of consideration. Washing the vagina with a 50 per cent. solution of cane sugar is employed. Thirty grams (1 ounce) of sugar dissolved in the same amount of hot water, allowed to cool to a bearable temperature, and then injected into the vagina after the woman has gone to bed and is ready to remain quiet for the night, is effective. This treatment may be used once a week.

The injection of 15 or 30 c.c. a thick suspension of yeast 2 or 3 times a week, followed by a tampon to prevent its escape, is useful. Or yeast may be used in the form of powder combined with the sugar treatment.

Cases of leukorrhea, in which the secretion is alkaline as is usually the case, may have the reaction of the vagina changed to acid by smearing the cervix with a tablet of Bulgarian *lactic acid bacillus* made into a paste. Such an application as this may be made once a week, and a more normal state of the vagina maintained.

Another method consists in swabbing the vagina with a 5 per cent. solution of silver nitrate, and then injecting 0.5 per cent. solution of lactic acid (see Endometritis and Vaginitis, pages 369 and 355).

Of the local applications which give most immediate results are powders which are drying, antiseptic and slightly astringent. Aluminum acetate (1 part), kaolin (2 parts) and talcum (2 parts) make a useful powder. Powders containing iodin or chlorin are valuable.

Improvement of the general health and improvement of the pelvic circulation are essential.

In *senile endometritis*, dilatation of the cervix often effects a cure; but if the cervix is normally patent, curettage should be added. The same treatment is indicated in *hemorrhagic endometritis*, and in *chronic proliferative endometritis*.

The treatment of *tuberculosis of the uterus* is constitutional. When the disease is confined to the uterus and tubes they should be removed.

Any form of chronic endometritis which does not yield to treatment should give rise to the suspicion of carcinoma or tuberculosis. When treatment fails, hysterectomy is the last resort. Patients with intractable hemorrhagic endometritis should not be temporized with long, but should be given the benefit of hysterectomy.

Acute metritis should be prevented. In *puerperal septicemia*, it was formerly assumed that the most important local measure consists in removing infective material from the interior of the uterus with the least possible traumatism to the uterine wall. Obstetricians and gynecologists have largely agreed that even the least traumatism is to be avoided, and advise against curettage, irrigation or any other mechanical interference. The policy of "do nothing" seems to have given better results than that of interference. Even though the whole placenta is in the uterus, it is advised to desist from interference. *A more reasonable application of this principle calls for the*

removal of any infected material which can be removed without causing wounds or abrasions. Improving the constitutional resistance is of greatest importance. The use of bactericidal drugs may have some value.

Preparations of mercury, arsenic, iodin, and silver have been used by some with apparently good results. Mercuric chlorid and mercuric cyanid are employed. The method of administration is by intramuscular injection. Mercuric cyanid 0.01 Gm. in 1 c.c. of water, with a little cocain, is injected daily for seven days. The drug is then omitted for seven days; and then if necessary, given again for seven days. Instead of the cyanid, the chlorid may be used. It is injected in the form of a 2 and 5 per cent. solution. One cubic centimeter of this is given twice daily, the weaker and stronger solutions alternating. When symptoms of mercurial poisoning appear, the drug is discontinued until they subside. Diarrhea and drop in the number of red blood-cells must be guarded against; the first by discontinuing the drug or by giving opium and, the second by discontinuing the drug and diluting the blood with saline solution. Quinin has been used more or less in this disease. But in recent years all of these measures, once popular, have fallen into disuse, and surgeons are relying more upon the natural forces of resistance.

Drugs have been used with doubtful results. It is the author's belief that the constitutional bactericidal effect of drugs is of such questionable value that the surgeon is justified in omitting them, and addressing his attention to improving the vitality of the patient.

The treatment with specific vaccines and bacterins is of doubtful utility. Better results have been secured with nonspecific serotherapy; intravenous injections of normal horse and beef serum are used. The dose need not exceed 20 c.c. Some surprising results have followed injections of nonspecific vaccines.

Treatment by the intra-uterine instillation of solutions of hypochlorite of lime or soda, dichloramin in oil or solutions of chlorazene have been much lauded by those who have been first to apply it.

In *septic abortion,* without fever, no local interference is indicated excepting in cases of hemorrhage. If abortion is in process but is not completed nature should be depended upon to empty the uterus. If examination is necessary it is best made by the rectum. Severe or continuous hemorrhage requires emptying the uterus. When this must be done, it is best to pack the uterus, and leave the packing for twelve, eighteen or twenty-four hours and then remove it. This should be done with the utmost care to avoid abrasions. When the packing is removed the fetal contents usually come away with it. If it does not, it should be removed manually. Further dilatation of the cervix with a rubber bag may be necessary. If the hand cannot be used gentle traction with forceps may be employed.

In *puerperal pyemia* the same general principles apply as in septicemia. There is this exception; in pyemia, definite knowledge concerning the infecting organism may be had, and definite isolated foci of infection may exist. Operation on the infected veins as a complication of otitis has been so successfully carried out, it would seem natural that the same principle might be applied in this disease. *Ligation or excision of the infected veins* in puerperal pyemia has given gratifying results in this most serious disease. Operation should not be done on the veins if the patient has acute peritonitis, metastatic abscesses, acute endocarditis, pneumonia or other remote acute infections. The indications for operation are the first signs of pelvic thrombophlebitis in the subacute and chronic forms. Operation is not to be advised in the fulminating and acute cases. Usually the acute stage lasts during the first ten or fifteen days. In some cases operation may be

done during the first week. Localization of infection in the veins is seen after the first eight or ten days.

Subperitoneal and vaginal approach to the infected veins has been abandoned as impractical. The broad ligaments are best exposed by the ordinary low abdominal incision. If a definite vein with thrombosing infection is discovered it should be tied and resected. Usually it will be better simply to ligate above the infection. The important object is to prevent infection entering the vena cava. Ligation accomplishes this. The common iliac vein may be tied on the infected side as a routine procedure in cases of phlebitis of the deeper veins. Infection on both sides calls for ligation of the iliacs on both sides. In cases in which infection extends into both common iliacs, ligation of the vena cava was recommended by Trendelenburg.

Many surgeons are opposed to these operations on the veins, but reserve operation for those cases only which have gone on to the development of abscess.

Chronic metritis should be treated the same as endometritis. In addition to this, benefit is secured by the following specific measures. The patient is put to bed. Every morning a large wool tampon, soaked in ichthyol (25 per cent.) and glycerin (75 per cent.), is placed against the cervix. At night this is removed and a hot douche of several quarts of water is given. This treatment is continued for two or three weeks if necessary. Good results may be secured with the use of the hot water alone.

Chronic pelvic disease, in which the relics of inflammation of the uterus and tubes give rise to persistent symptoms, may be relieved by the measures taken to relieve chronic metritis. Rest in bed and hot applications (hot air and hot fluids) are effective in some cases. Massage to the affected parts has been much used, but is tedious and requires much patience and time. Treatment by weighting (Belastung) gives good results in some hands.

The features of treatment by weighting are the use of the inclined plane, to give elevation of the pelvis, and the application of pressure. Pressure is made to the abdomen and in the vagina; it may be continuous or intermittent. Abdominal pressure is made with bags of shot or clay poultices weighing from 1 to 5 kilos (2 to 10 pounds). Intravaginal pressure is made by means of rubber bags filled with shot, air or gauze. This treatment by causing local anemia and local congestion dissolves adhesions and hastens the absorption of exudate.

Suction treatment is also employed, but probably with less advantageous results than in the more accessible parts.

Tumors of the Uterus.—*Polypus* within the uterus may be removed by grasping it with strong tenaculum forceps and twisting until the pedicle is twisted off. This can be done with polypus presenting at the vagina. In some cases these tumors are so large that the vulvar opening is too small for their exit. In such cases the tumor should be removed by morcellement. By this method the tumor is removed piece by piece, being cut to pieces in the vagina. If a ligature can be slipped over the tumor and tied, it should be done, otherwise bleeding should be controlled by packing the uterine cavity with gauze. A polypus retained within the uterus and too large to pass through the os may be reached by incising the cervix and body, if necessary, longitudinally in the median line (see Hysterotomy, page 401). Either vaginal or abdominal hysterotomy may be done, depending on the location of the tumor. The wound of the uterus is closed after the enucleation.

Fibromyoma of the uterus may be treated by enucleation, hysterectomy or

radiotherapy; or, if the woman is approaching the menopause, no treatment may be employed. Hysterectomy should be avoided if possible. In cases in which the fibroids are few in number and situated close to the surface, so that the structure of the uterus is not much damaged, their enucleation is the best treatment. The peritoneum is elliptically incised about the tumor, stripped back, the tumor shelled out and the peritoneal wound sutured with chromicized catgut (Fig. 1776). Fibroids lying just under the peritoneum or endometrium may thus be treated. Submucous fibroids may be approached through the vagina, the os dilated, the mucous membrane incised and the tumor shelled out.

When subperitoneal fibroids are removed by an elliptical incision near the base, enough peritoneum to cover the wound should be left. Bleeding is checked by carrying a ligature in a needle under the bleeding vessel. Where a number of large growths are present the uterine wall is much thinned,

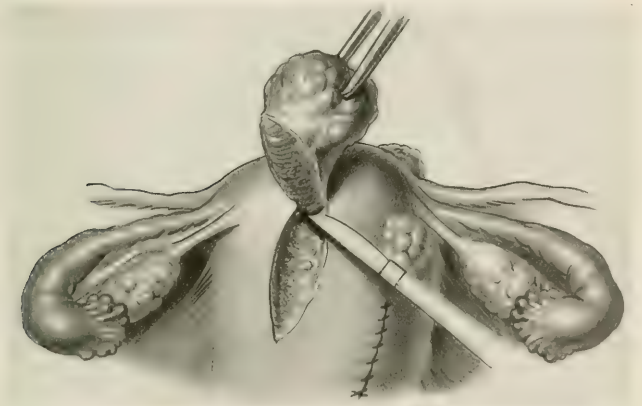


FIG. 1776.—ENUCLEATION OF SUBPERITONEAL MYOMATA.
One tumor has been removed and the wound closed; another is in process of removal; and a third remains still to be attacked.

and rupture of the uterus in subsequent pregnancy has followed their removal. In cases of fibroids in women under forty the removal of the growths alone is often followed by recurrence. In cases with diseased tubes and ovaries, rendering pregnancy improbable, enucleation of the growths may be done. The operation has been performed upon the gravid uterus with successful results for both mother and child. Rarely is operation during pregnancy necessary. The danger of abortion following operation is very great.

The surest and most generally applicable treatment of uterine fibroids is hysterectomy. The operation may be done through the abdomen or vagina. The vaginal operation is reserved for cases in which the suprapubic operation cannot be done. A large tumor can be removed through the vagina by morcellement. The high operation is to be preferred.

The *x*-rays and radium are used with pronounced success. They are not safe in rapidly growing tumors nor in fibroids complicated by pregnancy.

Some cases seem to undergo degenerative changes and produce dangerous toxins under the influence of radiation treatment. This treatment is tedious and uncertain in some cases; operation is prompt and curative. Because of the low mortality of operation, it must be regarded as the treatment of accuracy, if not of preference.

In the hands of skilled radiologists the *x*-ray and radium treatments of uterine myoma have been brought to a high state of efficiency. While the general surgeon is treating these cases by hysterectomy, the radiation treatment is steadily encroaching upon the field of cures with always improving results. Not only is this treatment curing a large proportion of these cases, but to its advantage it may be said that, if the patient is not cured, hysterectomy may still be done; whereas if hysterectomy fails as a primary treatment the failure is final and conclusive. The sacrifice of the uterus is never to be undertaken lightly (see Radiotherapy, page 703).

Carcinoma of the uterus should receive prophylactic consideration. It should be prevented by healing lacerations of the cervix and chronic inflammations of the womb and by delaying senescence. Women should be taught to recognize the early symptoms. They should apply at once to a physician for examination in case of irregular bleeding, especially after coitus, and in case of an ill-smelling brownish discharge. Women who have a return of bleeding after the menopause has become established should suspect cancer. The only hope of cure is in early removal of the cancerous disease or womb (see Hysterectomy, page 410). The public should be taught this.

Cases in which the disease is confined to the uterus are operable and curable. When the growth has invaded the neighboring structures, if not too widely, cure is still possible. If cure is not possible, still a palliative operation should be done.

Treatment by the application of heat, best applied by means of the *electric cautery*, is most useful for cases not amenable to hysterectomy. *Fulguration* (page 699) and *radiotherapy* (page 709) have much to offer. *Palliative operation* can prolong life and improve the comfort of the patient. The most simple and satisfactory palliative procedure consists in curetting out all of the broken-down tissue and then cauterizing the raw surface of the cavity with the actual cautery or with a chemical caustic (see Palliative Treatment of Malignant Growths, Vol. I, page 327). The cavity should be packed every two or three days with gauze treated with iodoform, iodin, chlorazene, chloramin, thymol, phenol, permanganate of potash, or other deodorizing antiseptic. Later, douches with these substances may be used daily to keep the parts clean (see Operations for Cancer of Uterus, page 410).

The treatment may be summarized as follows:

1. Cancer of the cervix, not so far advanced but that its boundaries are within surgical reach, is best treated by cauterizing the growth until its limits are apparently reached. This operation should then be followed by radical abdominal hysterectomy, and removal of pelvic connective tissue if the patient is in good condition.

2. If the general condition of the patient is not good, but the growth is not far advanced, cauterization followed by vaginal hysterectomy should be done instead of the abdominal operation.

3. If the general condition of the patient is decidedly bad, militating even against vaginal hysterectomy, the cautery operation alone should be done.

4. If the disease is advanced beyond the possibilities of eradication with the knife, and the patient is in good general condition, the cautery operation through the vagina should be done, the uterus cauterized down to a shell,

and the operation completed as an abdominal hysterectomy two weeks later.

5. If the disease is far advanced but the condition of the patient poor, the cautery operation should be done, and the question of later hysterectomy deferred.

6. Cancer of the body of the uterus is best treated by abdominal hysterectomy. If the condition of the patient is so bad that abdominal operation is contraindicated, vaginal hysterectomy may be done. In these latter cases the vaginal hysterectomy may be done with clamps and the cautery, thus saving blood and time.

7. Cases which belong to the category of the surgically hopeless may have much done for them by the cautery, followed by *x*-ray or radium (see Hysterectomy and other Operations for Cancer, page 410).

Sarcoma of the uterus should be treated by early hysterectomy.

Chorio-epithelioma should be treated by early hysterectomy.

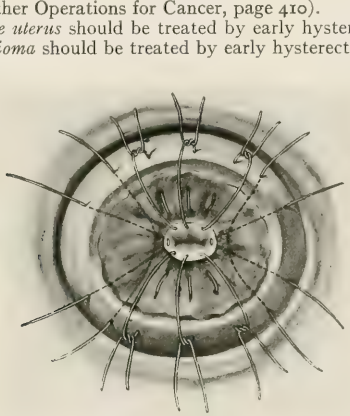


FIG. 1777.—AMPUTATION OF THE CERVIX.
Sutures placed after the cervix has been amputated.

Congenital Abnormalities.—*Stenosis of the uterus* should be treated the same as stenosis of the vagina.

Rudimentary uterus is not amenable to surgery.

Hypertrophy of the Cervix.—Amputation of the cervix is the only effective treatment.

Amputation of the cervix is indicated in *hypertrophy of the cervix*, in very early cases of *epithelioma* of the cervix, in some cases of *cystic degeneration* of the cervix, and in some cases of *procidentia*. When done for early cancer, the operation should be higher than usual, and embrace opening the peritoneum to attain the desired height. In some cases of ectropion, eversion and laceration of the cervix, a better result will be secured than by trachelorrhaphy.

The operation is performed after the same preparation as for trachelorrhaphy. Dilatation of the uterine canal should be done, and curettage, if indicated. The cervix is grasped by two tenacula and gently drawn down as for trachelorrhaphy. From points at the desired height at the sides of the cervix a curved incision is made behind and in front of the cervix marking out a posterior and an anterior flap (Fig. 1777). These flaps are dissected

back a short distance, and the cervix amputated between them. The cervical canal should be preserved at the apex of a wedge at a height on the level of the two flaps. Bleeding should be controlled by deep sutures. The flaps should be sutured together with chromic catgut excepting at the center, where each flap should be sewed to the mucous membrane of the cervical canal (Fig. 1778).

Displacements of the Uterus.—*Prolapsus* may be prevented by maintaining physical efficiency, preventing fatigue, and preventing and curing inflammations of the uterus, retroversion and lacerations of the perineum. The use of the *pessary* for supporting the uterus is an almost obsolete surgical procedure. Still under certain circumstances it is called for. A ball pessary of hard or soft rubber or other clean material, is fitted into the vagina; and, as it rests upon the levator ani muscle, holds up the uterus. Another form of pessary much in favor is that of Menge. It consists of a ring, which fits into the vaginal fornix; to a cross-bar a detachable stem is fixed which engages at the introitus and prevents rotation of the ring. In cases in which the

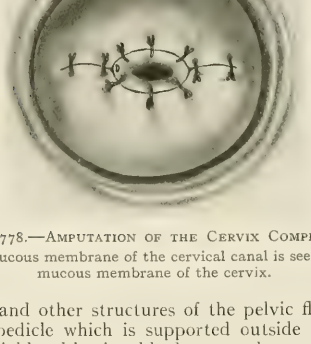


FIG. 1778.—AMPUTATION OF THE CERVIX COMPLETED.

Wound closed. The mucous membrane of the cervical canal is seen sewed to the externa mucous membrane of the cervix.

levator ani muscle and other structures of the pelvic floor are deficient, a pessary, having a pedicle which is supported outside by straps, is worn. These things are highly objectionable because they cannot be kept clean and because they produce irritation and sometimes ulceration. It should be borne in mind that prolapsus is always preceded by retroversion. If a uetrus is kept in a position of anteversion prolapsus is prevented.

The *operative treatment* of prolapsus varies with the character of the disorder. In cases of a mild degree, the surgeon should cure the chronic endometritis by dilatation, curettage and repair of the lacerated cervix; he should perform anterior colporrhaphy and fixation of the vagina to the white lines of the levator ani, repair the relaxed perineum, and hold the uterus in anteversion by shortening the round ligaments or performing ventrofixation. To improve the patient's general physical tone is also important. The amputation of an hypertrophied cervix is often called for.

Prolapsus *in young girls* or children is best treated by reducing the displacement and keeping the child horizontal for a period of weeks or months. Operation for the relaxed vagina and retroversion is necessary if this fails.

In the more advanced cases, in which the uterus protrudes through the introitus vulvæ, there is a relaxation of the pelvic supports and often a general intra-abdominal visceral ptosis. To remove the uterus or simply narrow the pelvic outlet does not cure the disease. The treatment of these cases is trying and often unsatisfactory unless approached with an understanding of the fundamental conditions. The patient should be put to bed, and the prolapsus kept reduced by the recumbent position or by pelvic elevation. This allows of subsidence of edema and an equalization of circulation. If the prolapsus can be kept reduced, it is well to keep the patient in bed for ten days or more, as a preparation for operation. Abdominal massage, intrapelvic electricity, and cold vaginal douches are of use in restoring muscular tone. If the uterus refuses to stay up, the vagina may be packed with gauze every second or third day. By using packing or tampons saturated with glycerin, as for chronic metritis, a healthier condition may be secured.

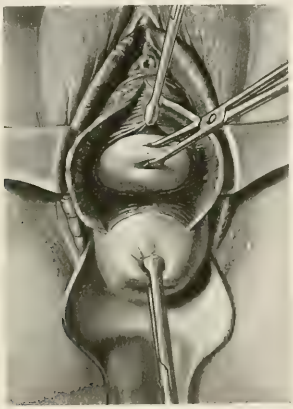


FIG. 1779.—OPERATION FOR PROLAPSE OF UTERUS.
The peritoneum is opened through the anterior fornix. The fundus of the uterus is pulled into the opening.

Operation should aim to hold up the uterus in a state of anteversion or it will fail. To remove the uterus is to sacrifice an important structure in the supporting floor, because the prolapsus is not alone of the uterus but of the vagina, bladder and pelvic ligaments as well.

If there is great relaxation of the vaginal wall an elliptical section should be removed from the anterior vaginal wall as for cystocele (page 343). This ellipse should extend from a point just behind the external urinary meatus nearly to the cervix.

If there is less relaxation only a longitudinal median incision need be made, which may have added to it a transverse incision at its upper end.

Dissection is then made outward, separating bladder from vagina. Then the dissection is carried upward between the bladder and uterus. Bleeding is checked. The vesico-uterine fold of peritoneum is opened, and the ante-

rior edge of peritoneum caught in a clamp. The fundus of the uterus is then tilted forward and brought downward through this opening, by a tenaculum (Fig. 1779). Some surgeons bring the fundus as far forward as the urethra. The vesical edge of peritoneum is sewed to the posterior surface of the uterus. The fundus is sewed to the vaginal wall by one or two fixation sutures. The vaginal wound is then closed over the uterus which now lies buried between bladder and vagina (Fig. 1780). The result is that, the fundus is thrown forward and the bladder held up; the cervix is thrown backward and the lateral uterine ligaments made more tense; and the anteversion of the uterus places that organ across the pelvic canal at right angles to its axis (Fig. 1781).

This operation of placing the fundus uteri under the bladder obviously should not be done in women who still are to bear children. It is only

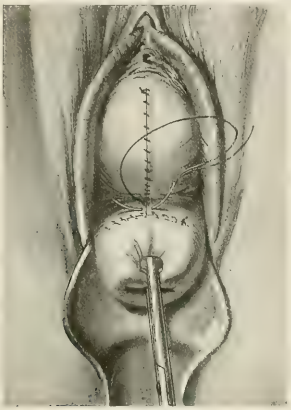


FIG. 1780.—OPERATION FOR PROLAPSE OF UTERUS COMPLETED.
Fundus sutured between bladder and vaginal wall.

justified in women who have passed the menopause or who are sterile. If necessary, sterility may be induced by resection of a segment of each Fallopian tube.

This operation of *uterine interposition* has been much used with apparent satisfaction. It is an unnatural procedure, and should be employed only in the cases in which a more natural restoration of the parts cannot be accomplished.

The next step in the operation consists in performing perineorrhaphy (page 335). In this the dissection should be carried well up and a large-sized inverted V of tissue should be removed from the posterior vaginal wall. The vaginal canal is thus narrowed and the perineal body restored.

In addition to these procedures, suspension of the round ligaments to the anterior abdominal wall may be required. This is done after the method of Gilliam (see Shortening of Round Ligaments, page 390).

In cases of younger women or women who are to bear children, the anteversion must be secured by shortening the round or broad ligaments

or by ventrosuspension of the uterus. It is often desirable to suture the lowest posterior surface of the uterus to the fold of peritoneum on either side of the rectum, thus giving additional suspension and anteversion.

P. A. Harris practised intramural sequestration and fixation of the uterus, whereby the organ is imbedded in the abdominal wall. M. L. Harris isolated and divided the tendon of the psoas parvus and attached it to the posterior wall of the uterus.

O. Walbaum (Zentralb. f. Gyn., Aug. 28, 1915, vol. 39, No. 35) made a septum in the vagina by denuding a strip anteriorly and posteriorly and sewing them together. By uniting the bladder and the rectum in this

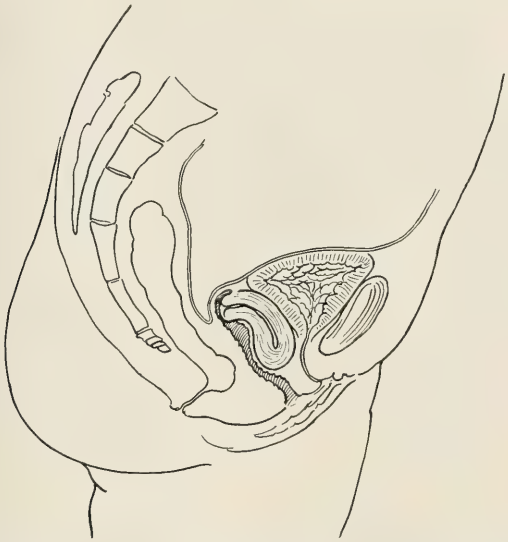


FIG. 1781.—DIAGRAM OF OPERATION FOR PROLAPSE OF UTERUS.
Showing result of the operation. The body of the uterus is seen displaced forward and fixed between the vagina and the bladder.

manner two tubes on either side are formed which give adequate uterine drainage. Perineorrhaphy should be done.

If the uterus is drawn down with a tenaculum, the finger in the vagina easily feels the sacro-uterine ligaments on either side. These ligaments in mild cases may be exposed in the vagina and shortened by plastic operation from below.

If hysterectomy is done, the broad ligaments should be sutured to the bladder and rectum in such a manner as to hold up these two viscera.

J. R. Goffe devised an operation based on the assertion that if the bladder and uterus are in normal position the pelvic floor is not concerned in their support. He dissected the bladder free from the vagina and uterus and moved the latter forward into a normal position of anteversion. The uterus

is held with a tenaculum and an incision made in the anterior fornix as for hysterectomy, and the bladder is separated from the uterus. The vaginal wall is then incised in the median line, the bladder lifted up, the vesico-uterine peritoneal pouch opened, and the round ligaments shortened through this opening.

Points on the bladder are then selected in such positions as will make its anterior surface taut, and these are secured to the uterus and on either side of the uterus to the peritoneum. When these sutures are tied the urethra should be drawn up so that its vesical end is lifted upward. After the

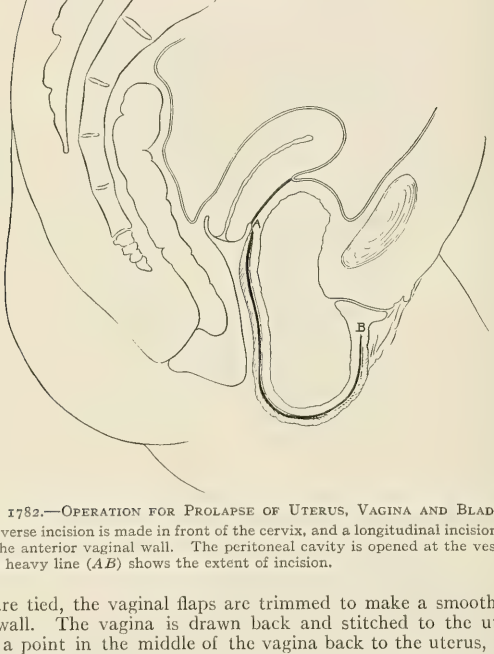


FIG. 1782.—OPERATION FOR PROLAPSE OF UTERUS, VAGINA AND BLADDER.

A transverse incision is made in front of the cervix, and a longitudinal incision the whole length of the anterior vaginal wall. The peritoneal cavity is opened at the vesico-uterine fold. The heavy line (*AB*) shows the extent of incision.

sutures are tied, the vaginal flaps are trimmed to make a smooth anterior vaginal wall. The vagina is drawn back and stitched to the uterus, by carrying a point in the middle of the vagina back to the uterus, in such a way as to shorten the anterior vaginal wall. This operation simply rotates the uterus and vagina forward and upward around the bladder (Figs. 1782 and 1783).

Some surgeons have made a long incision across the floor of the pelvis from buttock to buttock, overlapped the levator ani fibers and then superimposed a flap of gluteus maximus from either side, united in the median line to give a strong restoration of the pelvic floor.

Hysterectomy for prolapse is the surest cure. While a certain number

of cases may be cured by plastic operation, recurrence is very common and there always remains a large proportion of cases, obviously not amenable to such treatment. The prolapsus involves not only the uterus but bladder, vagina, and broad ligaments. So great is the danger of recurrence that in cases of complete prolapse, in women who are to have no more children, intra-abdominal operation should be advised. Plastic operation done from below does not suffice. The best operation is abdominal hysterectomy with low amputation of the cervix. The ligature which includes the ovarian artery and the round ligament should be placed far out to-

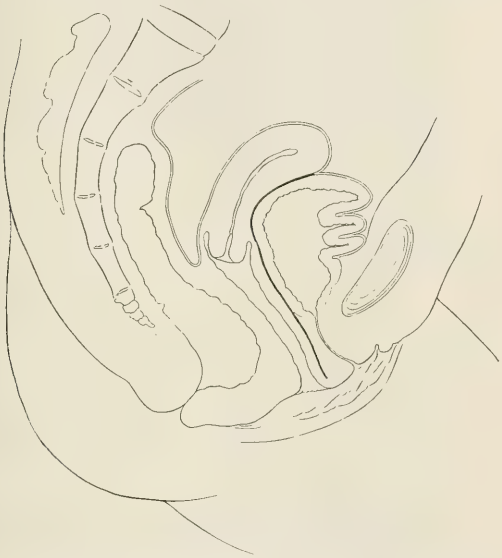


FIG. 1783.—OPERATION FOR PROLAPSE OF UTERUS, VAGINA AND BLADDER COMPLETED. The uterus has been lifted up, the round ligaments shortened, and the uterus and vagina rotated upward around the bladder.

ward the pelvic wall. The uterine artery should be ligated separately. The broad ligament stumps should be short, and should be sewed to the stump of the cervix (Fig. 1784). The peritoneal edge should be sewed over the stump (see Hysterectomy, page 410).

If the cervix has been amputated low and the broad ligament stumps made short the above operation will cure most cases. But in a certain proportion the relaxation of all of the structures is so great that even this fails. In these a suprapubic hysterectomy should be done, the broad ligament rent sewed as is usual after hysterectomy, and the stump of the cervix sutured to the anterior abdominal wall just above the bladder by sutures passing through all of the structures excepting the skin (Fig. 1785).

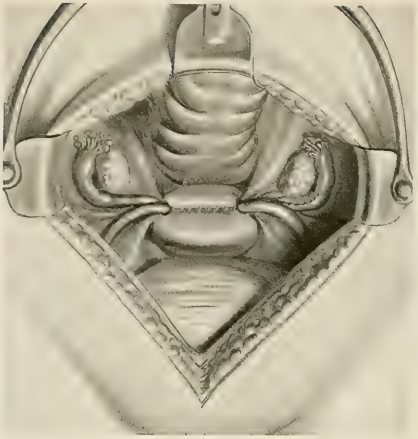


FIG. 1784.—HYSTERECTOMY FOR PROLAPSE.

The body of the uterus has been removed, leaving the cervix; the stump of the broad ligament is sewed to the cervix; and the peritoneum is sutured over the raw surfaces.

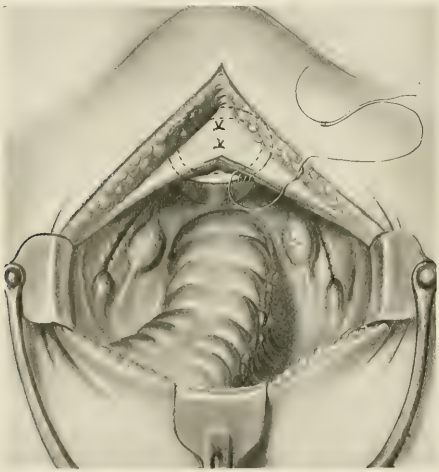


FIG. 1785.—HYSTERECTOMY FOR PROLAPSE, WITH VENTROFIXATION OF AMPUTATED CERVIX.

Suture of the cervical stump to the anterior abdominal wall. The uterus has been amputated above the cervix; the broad ligaments have been sutured; the cervical stump has been transfixed by two sutures and sewed in place below the abdominal wound. Note preservation of ovaries.

Inversion of the uterus, the condition in which the organ is turned inside out, should be prevented by preventing uterine inertia in labor, by refraining from making traction on the attached placenta or indenting pressure upon the fundus, and by removing intra-uterine tumors before they have produced inversion in the natural effort to deliver themselves.

In *recent cases* of inversion the placenta or tumor should be removed. The bowels should be evacuated. With the patient anesthetized and under strict asepsis the fundus should be pressed back following the axis of the pelvic canal. Pressure downward upon the cervix is made with the other hand above the pubes (Fig. 1786). Care should be taken not to tear the uterine wall. Pressure from below is best made with a pad of gauze. If such manipulation fail, the size of the uterine body may be reduced by grasping it evenly in the hands and squeezing it to expel the blood. In

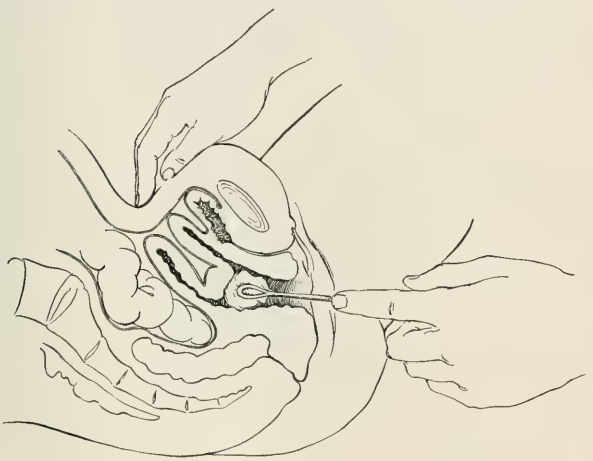


FIG. 1786.—REPLACEMENT OF INVERTED UTERUS.
A tampon of gauze held by forceps is used to press upward the fundus of the uterus.

such a case with much edema and threatened with hysterectomy, I once secured reduction by enveloping the organ in a rubber Esmarch bandage, beginning at the fundus. As the bandage was removed from the cervix toward the fundus, reduction was accomplished with ease.

Efforts at reduction failing, the patient should be put back to bed with the uterus covered with a wet boric acid dressing. As soon as the patient has recuperated a second attempt should be made. This failing on account of tightness of the cervix, the cervix should be divided in the median line anteriorly or posteriorly or both. Montgomery made a median incision through the posterior fornix and the cervix, brought the body down through this opening, replaced the uterus, and sutured the wound.

After reduction, the uterus should be tamponed with gauze. This may be left in for two days. Then a daily hot intra-uterine douche should be given and ergot administered, until contraction is secured.

In *chronic cases* of inversion, and unreduced recent cases, the treatment is not essentially different from the above. If there is a narrow vagina it should be dilated with a colpeurynter. The rectum should be emptied. Efforts at reduction failing, the cervix may be incised. Some surgeons open the abdomen above the pubes, dilate the cervix from above, and proceed with the replacement.

Most of these chronic cases respond to treatment by incision of the cervix and body of the uterus. The inverted uterus and vagina should be disinfected, the anterior fornix incised and the bladder separated from the uterus (Fig. 1787). The vesico-uterine fold of peritoneum is divided and the opening enlarged laterally. The funnel formed by the inverted uterus is exposed

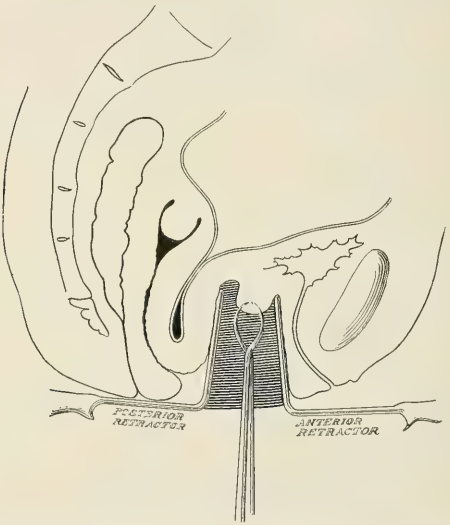


FIG. 1787.—OPERATION FOR INVERSION OF UTERUS.
Retractors are placed in front of the uterus and the anterior lip of the cervix is grasped by two tenaculum forceps.

and adherent structures separated from it. The cervix is then divided anteriorly in the median line, and the incision continued on through the anterior wall of the uterus as far as the fundus (Fig. 1788). This is done with care that no intestine is injured. As a precaution the inverted uterus may be packed with gauze on the peritoneal side.

The uterus is then inverted by simply folding it back upon itself. Before the wound can be sewed, it may be necessary to remove a segment of the thickened wall. A continuous suture of chromic catgut closes the uterine wound. If the wall is greatly thickened two layers of sutures will be necessary. Soiling of the peritoneum is apt to occur, and for this reason a drain opening should be made in the posterior cul-de-sac. A drain also should be left in the anterior fornix.

Amputation of the inverted uterus above the cervix should be preceded by median section of the organ to be sure that it contains no bowel and to press back the ovaries if they are engaged. Strong ligatures are then thrown about the structures containing the uterine arteries. The rest of the uterus is ligated in sections. If there is fear of peritoneal infection, a small tube containing a wick drain should be placed in the cervical opening. The tendency of the cervix to replace itself demands that the ligatures be tied with extraordinary security.

If the uterus is gangrenous or infected *hysterectomy* should be done. The cervix is split in the middle line and a transverse incision made at the anterior fornix. By dissecting between bladder and vagina the cervix is liberated. Ligatures are placed on the inverted broad ligaments and the vaginal wall at the fornices, as these structures are divided.

FIG. 1788.—OPERATION FOR INVERSION OF THE UTERUS.
The inverted uterus is split anteriorly in the middle line.

Anteversion and anteflexion of the uterus, beyond the normal degree, may be regarded as symptoms of other pathological conditions, which require treatment. Treatment simply to change the position of the uterus, if no symptoms are caused by it, is not indicated. The uterus may have a wide range of anteversion without harm. Not the surgeon, but the symptoms should decide whether the anteversion is beyond the normal. Dysmenorrhea, tumor, constipation, inflammatory deposits, or other allied conditions may demand treatment. The most common complications are narrowed os uteri and chronic endometritis. Dilatation of the uterine canal, curettage, and treatment with glycerin tampons are the measures usually employed. A few bi-weekly dilatations, followed by a few bimonthly dilatations, is often all that is required. The best cure is pregnancy.

Lateroversion and lateroflexion of the uterus, usually due to inflammatory deposits, when productive of symptoms, may be relieved by systematic pelvic massage, hot douches, and tamponade of the vagina, as employed in chronic metritis.

Retroversion and retroflexion of the uterus should be treated by improving the hygiene of the patient. Fresh air, normal exercise, avoidance of tight waist constriction, and correction of constipation are essential. Metritis

FIG. 1789.—BIMANUAL CORRECTION OF RETROVERSION OF THE UTERUS.
Fingers passed behind uterus tilt the organ forward.

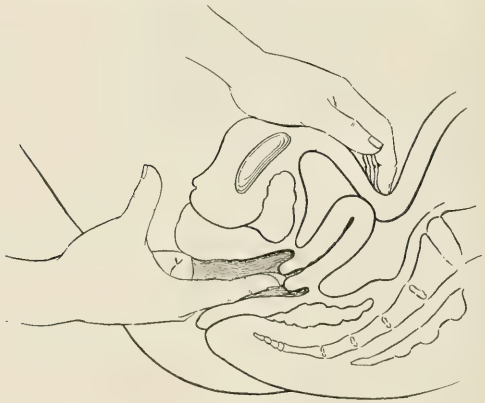


FIG. 1790.—BIMANUAL CORRECTION OF RETROVERSION.
The fingers in the vagina press the cervix backward and upward while the hand on the abdominal wall presses the fundus downward.

should be cured. At night for a time and during the day occasionally the patient should take the knee-chest position or lie upon the abdomen or the side with the pelvis rotated forward. The uterus can be made to drop for-

ward by assuming the knee-chest position and admitting air to the vagina by inserting the nozzle of a syringe. A glycerin tampon as for metritis may be inserted after the uterus has been thrown into anteversion. Pregnancy is the most effective cure.

FIG. 1791.—BIMANUAL CORRECTION OF RETROVERSION COMPLETED.

Treatment by *pessaries* is indicated in cases which do not yield to hygienic measures or cure of a causative condition, and in which operation is contra-indicated. The uterus should first be placed in anteversion. This may be done in the dorsal position by inserting two fingers in the vagina,

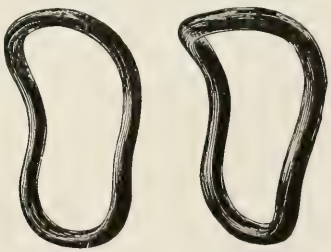


FIG. 1792.—PESSARIES FOR THE TREATMENT OF RETROVERSION.

and pressing the cervix backward with the index-finger and pressing the body forward with the middle finger in the posterior fornix. Or the fingers may lift the uterus forward from behind (Fig. 1789). The other hand, pressing down the abdominal wall above the pubes (Fig. 1790), catches the fundus

and presses it forward toward the bladder (Fig. 1791). Instead of the two fingers in the vagina, the anterior lip of the cervix may be grasped with a tenaculum and pushed backward while a long curved clamp, carrying a gauze sponge, is passed into the posterior fornix, and used to tilt the uterus forward. If the fundus impinges against the promontory of the sacrum, a finger in the rectum will press it forward.

The surgeon may be sure that anteversion has been secured when he can catch the fundus above the pubes through the abdominal wall. These manipulations are only of service when the uterus is movable. They are not to be undertaken if the uterus is held by adhesions.

If there has been retroversion for some time, prolapsus also will be found and a pessary cannot be worn until the vagina has been lengthened by using tampons for a period.

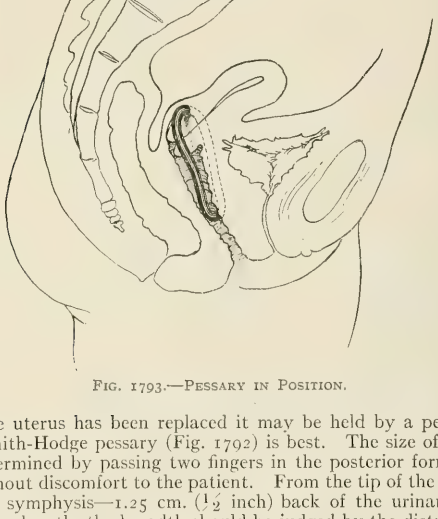


FIG. 1793.—PESSARY IN POSITION.

After the uterus has been replaced it may be held by a pessary. The so-called Smith-Hodge pessary (Fig. 1792) is best. The size of the pessary may be determined by passing two fingers in the posterior fornix as far as possible without discomfort to the patient. From the tip of the finger to the back of the symphysis—1.25 cm. ($\frac{1}{2}$ inch) back of the urinary meatus—represents the length; the breadth should be judged by the distance the two fingers can be separated in the vagina.

The pessary should fit well. If it cause undue pressure at any part, ulceration may result. The pessary is introduced after the uterus has been replaced. It is passed into the vagina and then rotated transversely. Its function is to lift up the posterior fornix of the vagina (Fig. 1793). It is contraindicated when adhesions are present; and it is not used in the virgin. In extreme retroversion it is of no value. Adhesions, which prevent permanent replacement, and pelvic tenderness are contraindications to the use of the pessary.

Retroversion, originating in childbirth or miscarriage, should be watched

for. Every woman after confinement before she begins to go about should be examined. If retroversion is found, the uterus should be replaced and the patient instructed to assume the knee-chest position for half an hour at night and then lie on the abdomen while going to sleep. The uterus in these cases is heavy and infiltrated, and therefore a pessary is contra-indicated. Six weeks after the puerperium, when involution is complete, the uterus should be examined again. If retroversion is found, treatment by pessary and hygiene is indicated. In combination with the pessary, abdominal massage and gymnastics to strengthen the abdominal muscles are of value.

FIG. 1794.—INGUINAL SHORTENING OF THE ROUND LIGAMENTS.
Operation of Alexander. The round ligament has been drawn out and caught with sutures. The insert shows fascia sewed over wound.

Retroversion, originating in traumatism, such as a fall, should be recognized by pelvic pain and backache, and treated at once by replacement and the prone position.

Recent cases of retroversion, if a cure is not accomplished with a year of treatment, should be regarded as chronic, and operation employed.

Chronic retroversion, if the case has had no previous treatment, should be treated by replacing the uterus and holding it by a pessary, while the measures to improve the general health of the patient are applied. After eight weeks of treatment by pessary, posture, hygiene, and abdominal gymnastics the pessary should be removed. If there is recurrence of the retroversion, operation is indicated. The patient should be given the choice of operation or of wearing a pessary indefinitely.

Operations for retrodisplacement of the uterus should be combined with division of any adhesions which hold the uterus in its abnormal position. Many operations have been devised. In selecting an operation the surgeon should consider the possibility of future pregnancy, as some procedures which are applicable to women after the climacteric are capable of doing much harm in the event of pregnancy. In operating for retrodisplacement, other associated conditions such as lacerations of the cervix and perineum, or visceroptosis, should receive surgical attention at the same time. Prolapsus of the uterus requires operation for prolapsus; it will not be cured by any of the usual operations adapted to retroversion.

Shortening of the round ligaments is the most useful procedure. *Alexander* accomplished this by making an incision about 6 cm. (2¼ inches) long on

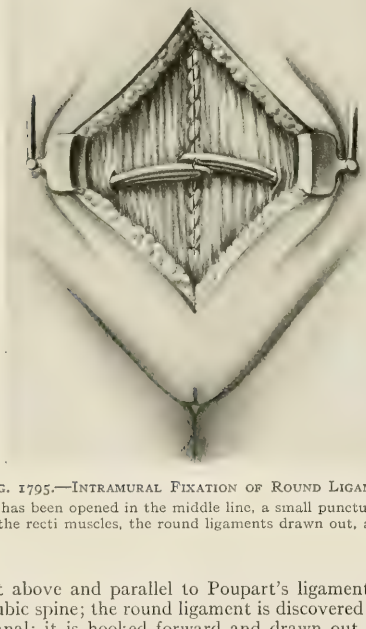


Fig. 1795.—Intramural Fixation of Round Ligaments.

The abdomen has been opened in the middle line, a small punctured opening made on the outer side of the recti muscles, the round ligaments drawn out, and sewed in front of the fascia.

either side just above and parallel to Poupart's ligament and terminating below at the pubic spine; the round ligament is discovered lying in the fat in the inguinal canal; it is hooked forward and drawn out from 4 to 10 cm. (1½ to 4 inches) until a moderate degree of tension is exerted—and sutured to the pillars of the inguinal canal (Fig. 1794). Some surgeons split the anterior wall of the canal and close it as for operation for hernia. This operation should not be done if adhesions hold the uterus. The outer portion of the ligament is often very delicate, difficult to find, and not strong enough to serve for suturing. Some surgeons have opened the inguinal canals so as to

pass the finger into the abdomen and separate adhesions, or do other operations, before suturing the ligaments.

Fixation of the round ligament in the abdominal wall has much to recommend it. This may be done as follows: a transverse curved incision, about 10 cm. (4 inches) long, is carried across the lower abdomen, through skin and superficial fascia from a point just internal to each internal abdominal ring. The abdomen is opened vertically in the median line to permit inspection and the necessary treatment of the pelvic organs (see Transverse Incisions for Opening Abdomen, Vol. II, pages 504 and 512). Curved forceps are

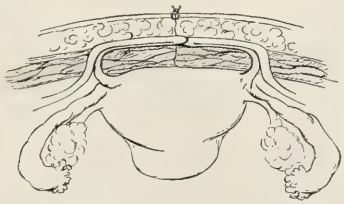


FIG. 1796.—INTRAMURAL FIXATION OF ROUND LIGAMENTS.
Diagram showing course of ligaments in abdominal wall.

passed through the rest of the abdominal wall at the end of this incision. The forceps are opened a little to enlarge the passage. The round ligament is then grasped at a point about 4 cm. (1¼ inches) from the horn of the uterus. The ligament, with its peritoneal covering is drawn out with the forceps through the punctured wound and fixed to the abdominal wall by a few chromic catgut sutures. The same operation is done on each side (Figs. 1795 and 1796).

Gilliam passed a silk thread around the ligament and grasped this with the forceps instead of grasping the ligament itself. Mayo and Barrett

FIG. 1797.—POSTMURAL FIXATION OF ROUND LIGAMENT.
The round ligaments are sewed to posterior surface of anterior abdominal wall.

suggested passing the forceps subperitoneally between the layers of the broad ligament. The French surgeons draw the ligament out through the space between the two tendons of the rectus muscle at their attachment to the pelvis.

The advantage of this over the operation of Alexander is that the strong part of the ligament is grasped. Equal tension should be applied to the two sides so that the uterus shall be drawn forward in the median line and not tilted

to one side. Some surgeons prefer to incise the broad ligament and draw out the round ligament thus drawing less tissue through the abdominal wall. The Fallopian tube should not be injured. Instead of a transverse incision, a median incision may be used and the superficial fascia dissected from the muscle for about 5 cm. (2 inches) on either side.

After drawing out the ligament in these operations, it is laid on the deep fascia and sutured to it, and then the superficial fascia and skin are closed over all.

Intra-abdominal fixation of round ligaments is much employed. The abdomen is opened by the low median incision and the pelvic organs given the necessary attention. The uterus is grasped and placed in the desired position. The round ligament is then picked up at its extreme outer end and,

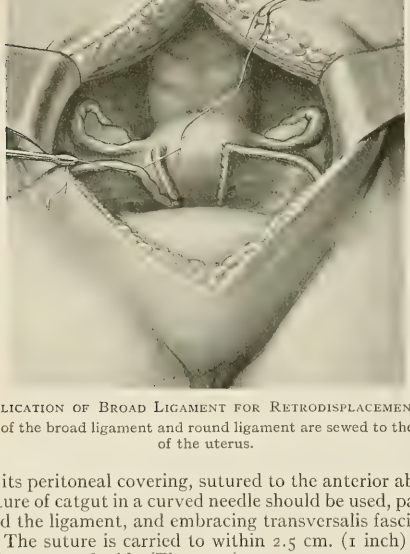


FIG. 1798.—PLICATION OF BROAD LIGAMENT FOR RETRODISPLACEMENT OF UTERUS. An anterior fold of the broad ligament and round ligament are sewed to the anterior surface of the uterus.

together with its peritoneal covering, sutured to the anterior abdominal wall. A running suture of catgut in a curved needle should be used, passing through but not around the ligament, and embracing transversalis fascia and parietal peritoneum. The suture is carried to within 2.5 cm. (1 inch) of the uterus. The same is done on each side (Fig. 1797).

Plication of the anterior fold of the broad ligament was recommended by R. C. Coffey, who sutured the folded ligaments to the anterolateral aspect of the uterus (Fig. 1798).

Retro-uterine plication of the round ligaments must be carefully performed lest it leave a raw surface to which the bowel may become attached. The operation is done by piercing the broad ligament from behind forward with forceps, catching the round ligament, drawing it through folded upon itself, and sewing it to the posterior surface of the uterus to meet the fold of its fellow from the opposite side (Fig. 1799).

Ventrosuspension of the uterus means sewing the fundus of the uterus to the anterior abdominal wall just above the bladder. It should not be done in a woman who may yet bear children as enlargement of the uterus is interfered with and miscarriage is apt to occur. The operation is done in cases of large heavy uterus, in cases with bad adhesions, in very fat women, and where prolapsus is marked. It results in adhesion between the fundus of the uterus and the abdominal wall which tends to stretch and become elongated into a cord, which later may allow recurrence or be the cause of intestinal obstruction. The operation is as follows:

The abdomen is opened low down in the median line. The uterus is grasped at the fundus with a tenaculum, and drawn forward. Adhesions are

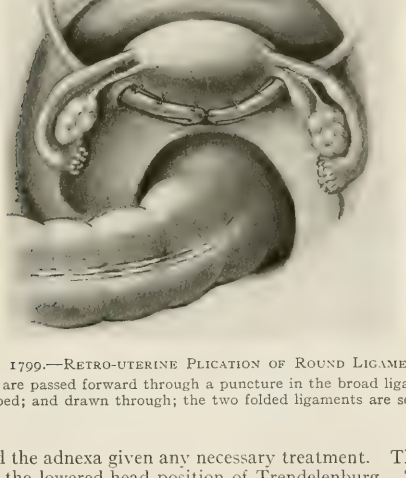


FIG. 1799.—RETRO-UTERINE PLICATION OF ROUND LIGAMENTS.

Long forceps are passed forward through a puncture in the broad ligament; the round ligament is grasped; and drawn through; the two folded ligaments are sewed to the back of the uterus.

separated, and the adnexa given any necessary treatment. The operation is facilitated by the lowered head position of Trendelenburg. Three chromic catgut sutures are used. These are passed through the transversalis fascia and the peritoneum and transversely through the uterine tissue for a distance of 1.25 cm. (½ inch) and about 6 mm. (¼ inch) deep. The area between the sutures is scraped to insure adhesions, and the sutures are tied in the wound (Fig. 1800). The toilet of the abdomen is finished, and the rest of the wound is closed as usual.

Anterior peritoneal fixation is accomplished by opening the abdomen in the median line, and making a transverse incision at the vesico-uterine fold of peritoneum extending out on either side into the anterior leaf of the broad ligament; the peritoneum is dissected up from the bladder, and the fundus of the uterus is brought forward and sewed to the lifted-up peritoneum. This operation holds the fundus forward and keeps the anterior surface of the body of the uterus in contact with the bladder.

Fascia fixation is accomplished by means of a strip of fascia, about 7 mm. (¼ inch) wide, cut from the rectus sheath on either side of the wound. The strips are left attached at the lower end of the median abdominal wound. The posterior aspect of the uterus is tunneled by a stab at the level of the attachment of the round ligaments. Through this the strips are drawn, one from each side, and sewed in place. This is the operation advocated by J. M. Allen (Surg., Gyn. and Obst., November, 1916).

J. V. D. Young (Am. Jour. Obst., February, 1916) devised an operation for shortening the uterosacral ligaments by removing a segment and suturing the wound. This operation gives the fundus of the uterus its normal pitch forward, and possesses the special merit that it leaves the fundus free and

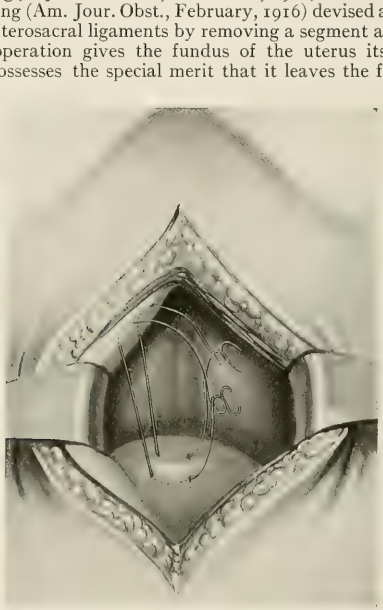


FIG. 1800.—VENTRAL SUSPENSION OF THE UTERUS.
Sutures through the fundal wall catch the peritoneum and transversalis fascia.

unrestrained by fixations. Any operation which hampers the mobility of the fundus must be looked upon as a defective surgical procedure. Young has demonstrated the possibility of curing retroversion of the uterus by sacral suspension. His operation should be regarded as the operation approaching nearest the surgical ideal.

Dysmenorrhea.—Painful menstruation is a symptom the cause of which should be searched for and treated. Reflex causes should be looked for and corrected. Eye-strain should be relieved.

There are in the nose certain locations which have to do with the genital apparatus, and which Fliess has designated as "genital spots." These are located at the tubercle of the septum and in the anterior portion of the inferior turbinate. It is noted that at menstruation and other sexual epochs these areas become congested and swollen. If these nasal areas are touched

with 20 per cent. cocain solution the pain is usually checked in from five to eight minutes. If only the turbinates are treated the headache ceases but not the abdominal pain; if treatment is applied only to one side the abdominal pain on the opposite side is relieved. Relief lasts until the effect of the cocain wears off. Adrenalin and certain other drugs seem to have the same effect. Electrolysis, galvanocautery and trichloracetic acid seem to have more permanent effects. By applying cocain the acid may be used without pain. A slough forms and clears up in a few days. Several such applications may be made.

Enchondroses in the nose may require to be removed, or other lesions which cause irritation of the "genital spots" in the nose.

The use of atropin, 0.5 or 0.6 mg. ($\frac{1}{120}$ or $\frac{1}{100}$ grain), thrice daily by stomach, beginning two days before menstruation is expected, exerts a decided influence in relieving the colicy pains. Sodium bromid, 1.6 Gm., and elixir of valerianate of ammonia, 4 c.c., every hour till relieved, are useful

Retroflexion, anteflexion, narrowing of the uterine canal and elongation of the cervix are to be met by appropriate treatment for these conditions.

In a large proportion of cases no positive cause can be identified but relief may still be secured by improving the general health. Hot vaginal douches, sitz-baths, counterirritation to the lower abdomen and rest are of value. Relief is often secured by the same treatment as is employed for stenosis of the canal.

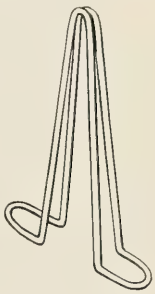


FIG. 1801.—INTRA-UTERINE WIRE PESSARY.

The stem pessary has great value. The uterine canal should be dilated under general anesthesia. If there is endometritis it should be curetted. A sterilized wire or stem pessary (Fig. 1801) is then introduced. It should be about 6 mm. ($\frac{1}{4}$ inch) shorter than the uterine canal. The patient should stay in bed for two days. She may then get up and go about with the pessary.

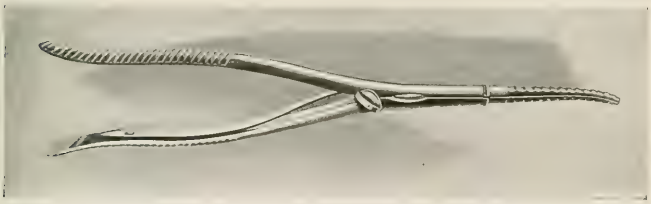


FIG. 1802.—UTERINE DILATOR.

It is possible to secure the same results by gradual dilatation. This may be done with the dilating sound or with the two-bladed dilator (Fig. 1802). The operation may be done twice a week every two weeks before menstruation. As the pain becomes less the intervals between dilatations may be increased. Most women can stand the operation without anesthetic, as the pain stops as soon as the dilator is removed.

General hygienic treatment in all of these cases is necessary. Seda-

tives for the attacks of pain are of some service. Pregnancy usually cures dysmenorrhea.

Tubal and ovarian forms of dysmenorrhea require treatment of the diseased appendices.

Ovaries which are caught in adhesions or surrounded by sclerotic tissue may require to be liberated or the sclerotic envelope may need to have a wedge resected to relieve tension.

There are certain *abdominal exercises* which are useful in dysmenorrhea and menorrhagia. They are the exercises which bring into play the muscles of the abdomen. C. D. Mosher (Jour. Am. Med. Assoc., Apr. 25, 1914) recommended the following: The woman lies on the back, in loose clothing. The knees are flexed, and the arms lie at the sides, to secure relaxation. She is then instructed to protrude forward the anterior abdominal wall as far as possible by lowering the diaphragm and relaxing the abdominal muscles; and then to depress the anterior abdominal wall as far as possible. This should be done smoothly and rhythmically ten times. The exercises may be taken two or three times daily for a week or two before menstruation.

Dysmenorrhea of ovarian origin has been cured by *resecting the spermatic nerve plexus*. This is done by incising the infundibulopelvic ligament, picking up all the tissue between the two layers of peritoneum, ligating it in two places, and resecting the intervening mass. This removes about 2.5 cm. (1 inch) of tissue, containing the vessels and nerves which go to the ovary.

It is maintained that in some cases the pain is due to spasmodic contraction of the muscles of the internal os, and a cure is best effected by a *resection of the muscle*.

In conclusion it should be emphasized that promiscuous treatment by dilatation and curettage are unsurgical. Treatment should be based on the diagnosis. Obstructive cases alone should be treated by removing obstructions. The ovarian cases call for the local treatment of ovarian disease, intranasal treatment and hypodermic injections of adrenalin. Cases due to vasomotor reflex unbalance are relieved by large doses of atropin begun a day or two before the menstrual period.

Menorrhagia and Metrorrhagia.—These symptoms call for treatment of their cause. The patient should be kept in bed. Endometritis most commonly demands treatment. Tumors, sclerosis of uterine vessels and constitutional diseases may require attention. When curettage or other treatment of the causative disease fails, the general principles applicable to hemorrhage should be applied.

The treatment of the hemorrhage, independent of the cause, demands that the patient should be kept as quietly in bed as possible. The more quiet she can lie the better. There should not only be physical but mental quiet. The patient should be kept in bed a few days after the hemorrhage has stopped. The bowels should move daily. The food should be simple. But little fluid should be taken. Medicines such as calcium lactate, supposedly having the power to increase the coagulability of the blood, may be of value.

If menstruation is prolonged, excessive and serious, it may be checked by packing the vagina with gauze or other tampon material.

In cases in which no cause is known, curettage and the application of phenol or iodin to the endometrium often cure the disease.

Intra-uterine tampon is recommended only as a resort when the other methods have failed. It is dangerous to repeat the operation as the possibility of infection with repeated tamponade is very great.

The application of live steam (atmokausis) to the endometrium by means

of special apparatus gives satisfaction in some cases. It is not a safe operation.

The removal of the uterine mucosa may be done in cases in which hysterectomy is called for. The uterus is incised in the median line and the endometrium excised. The fornices are excised, and the Fallopian tubes removed. The uterus is then sewed through-and-through to prevent hemorrhage.

Hysterectomy is performed as a last resort in cases in which the above measures have been indicated and have failed.

The use of electricity, the *x*-rays, radium and drugs are of value in some cases (see Uterine Hemorrhage, pages 699 and 709).

Amensia.—This condition when pathologic, requires general and local hygienic treatment or surgical removal of the cause. If there is *absence of generative organs*, there is no treatment. *Infantile uterus* may be stimulated by dilatation, and electricity. In the *masculine type* of woman nothing can be done. Amenorrhea due to *airesia* requires operation.

Special Operations on the Uterus

The **preparation** for operations on the uterus are essentially the same as for other operations (see Preparation for Operation, Vol. I, page 176). Operation usually is best done at a period midway between menstruations. In emergencies or in cases of metrorrhagia operation must often be done in the presence of bleeding. As a preliminary to operation any infective condition of the vagina should have been cured.

For vaginal operations the vulva and pubes may be shaved. This guarantees the best cleanliness, although it is not absolutely necessary. It is possible to sterilize the pudendal hair with iodin or other skin-sterilizing chemical. The patient is placed in the dorsal position at the foot of the table with the knees and thighs flexed, but not so acutely as to invite danger of thrombosis in the vessels of the legs. The pelvis should be elevated on a sand pillow or support. The region of the vulva, anus, and lower abdomen should be cleansed as for any operation. The vagina should be washed out with sterile running water and soap. Soft soap is used on a gauze mop. The soapy water is washed out with running water, and vaginal retractors or speculum introduced. The cervical canal should be cleared of mucus by means of a probe wound with gauze, and then sterilized with iodin.

The legs, feet, and trunk should be covered. A sterile sheet is used. Thigh boots of canton flannel are to be preferred as a covering for the legs. Only the vulva should be exposed.

In order to secure the exposure of the uterus various forms of two-bladed (Fig. 1803), trivalve, bivalve (Fig. 1804), and single-bladed specula are used. For dilatation and curettage, tenacula (Fig. 1805), dilators, and curets (Fig. 1806) are used. Sponges are best handled on long holders or clamps. A ligature carrier (Fig. 1807) is useful for deep cavities. Long clamps and pedicle clamps (Fig. 1808) are needed for deep operations.

The **gynecologic postures** for operations through the vagina are many. The most useful is the *dorsal position*, with the thighs and legs flexed (Fig. 1739, page 336). This is the position employed for most operations not only through the vagina but in the whole anopudendal region. The *elevated perineal position* is the same with the addition of a sand-bag or other device for elevating the pelvis.

The *lateral position* was employed by Sims. In this the patient lies on the table on her right side with her right arm behind her back. The left shoulder

is depressed toward the table. Both knees are drawn up, the left knee higher than the right (Fig. 1809). In this position the speculum of Sims or any single-bladed retractor may be employed. In the *knee-chest position*, the patient kneels on the table with the knees slightly separated. The thighs should be nearly perpendicular. The chest should lie against the table and as near the knees as possible in order to secure the highest elevation of the pel-

Fig. 1803.—Sims' Two-bladed Speculum

vis (Fig. 1810). The *knee-chest elevated position* is secured by placing the patient in the knee-chest position and raising the pelvis by pillows under the knees.

Vaginal retractors and specula should be introduced with their dimensions conforming to those of the vulva, and then rotated into place or opened. If the vulva is small a lubricant should be used. In the lateral position a single-bladed retractor, or the retractor of Sims, is used, and traction made ver-

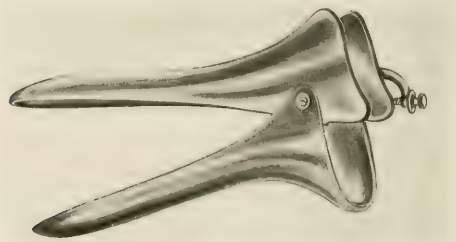


Fig. 1804.—Bivalve Speculum.

tically in the direction of the left sacro-iliac joint. Often two single-bladed retractors give the best exposure in the lateral and knee-chest position. In both of these, air enters and distends the vagina.

Dilatation of the uterine canal is done as a curative measure and as a preliminary to other operations. The strictest asepsis is imperative. The surgeon is often called upon to remove septic material from the uterus;

but for the surgeon to convey septic material into an uninfected uterus is unpardonable. The divulsing dilator is the best instrument (Fig. 1802, p. 395).

After the patient is placed in position, *cleansed*, and covered, a vaginal speculum is introduced. In order to steady the uterus, the anterior lip of the cervix is grasped with a tenaculum. The mouth of the uterus should be cleansed, and the cervical canal swabbed with iodin. The surgeon should know the position of the uterus by previous bimanual examination, or a sound should be introduced to determine the length and direction of the canal

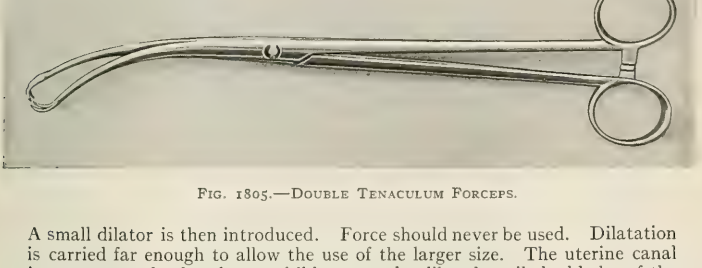


Fig. 1805.—Double Tenaculum Forceps.

A small dilator is then introduced. Force should never be used. Dilatation is carried far enough to allow the use of the larger size. The uterine canal in a woman who has borne children may be dilated until the blades of the dilator have been separated until the register on the handles show dilatation of 2.5 cm. (1 inch) or more. The dilatation should be done gradually, not rapidly, and then maintained for two or three minutes. The dilator is then released and withdrawn. The uterine cavity is now ready for operative approach or treatment.

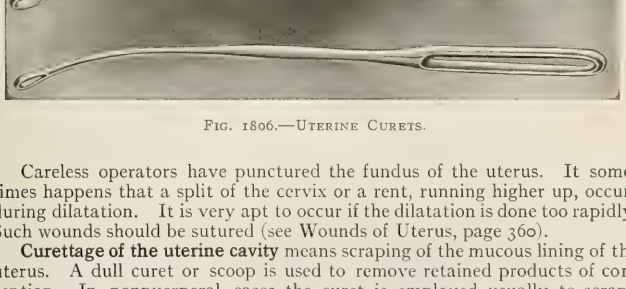


Fig. 1806.—Uterine Curets.

Careless operators have punctured the fundus of the uterus. It sometimes happens that a split of the cervix or a rent, running higher up, occurs during dilatation. It is very apt to occur if the dilatation is done too rapidly. Such wounds should be sutured (see Wounds of Uterus, page 360).

Curettage of the uterine cavity means scraping of the mucous lining of the uterus. A dull curet or scoop is used to remove retained products of conception. In nonpuerperal cases the curet is employed usually to scrape

out the diseased mucosa or remove carcinoma which is not to be subjected to radical operation.

For the removal of products of conception a large dull curet should be used with the utmost gentleness so as not to inflict damage to the natural protective lining of the uterus. Curettage which causes abrasion of the endometrium is contraindicated in acute infections.

In *chronic endometritis* curettage is done with a sharp curet. The uterus should be steadied by traction on the tenaculum grasping the cervix. The curet is then introduced (Fig. 1811), and the diseased mucous membrane

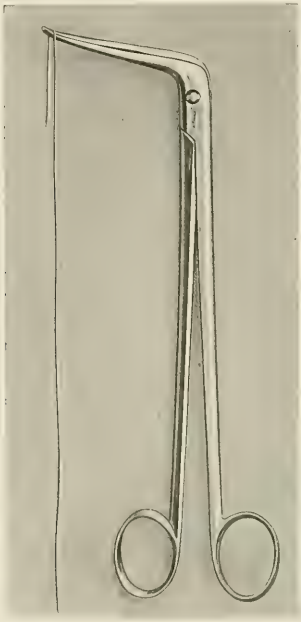


Fig. 1807. Ligature Carrier.

scraped out by drawing the curet from above downward. This should be done with enough force to remove the mucosa down to the firm submucous tissue. The experienced touch distinguishes. The curetting should begin at a definite line and systematically proceed around the uterus. The surgeon need not fear that removal of the endometrium may cause stenosis. The mucous membrane cannot be removed by this means because of the follicles which pass down into the muscular substance of the uterine wall and which serve as islands from which the endometrium is renewed.

Force should not be used in introducing the curet. If it does not enter easily, the dilator should again be used. The curettage should remove all

of the soft and swollen mucosa and leave a firm base lining. This can be done only with a sharp curet.

After completing the curettage, the uterus should be washed out with sterile water until the fluid returns clean. This is best done with a small catheter which allows the return fluid to escape around it. A pad should be applied to the vulva. The patient should be kept in bed about a week after curettage. *Perforation of the wall of the uterus* with the curet, into the

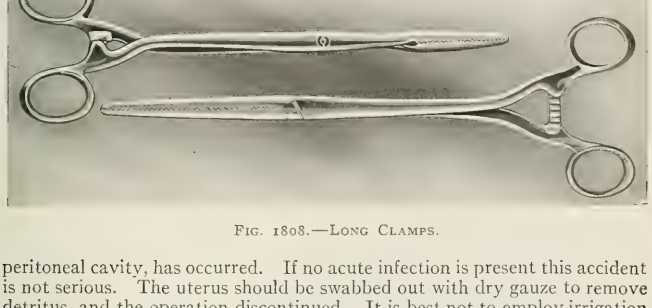


FIG. 1808.—LONG CLAMPS.

peritoneal cavity, has occurred. If no acute infection is present this accident is not serious. The uterus should be swabbed out with dry gauze to remove detritus, and the operation discontinued. It is best not to employ irrigation nor the gauze drain after this accident.

Hysterotomy.—The operation of cutting open the uterus is done usually for the removal of a child, polypoid tumor, foreign body, or mucous membrane (for Methods of Suture, see page 407). *Cesarean section* is done for

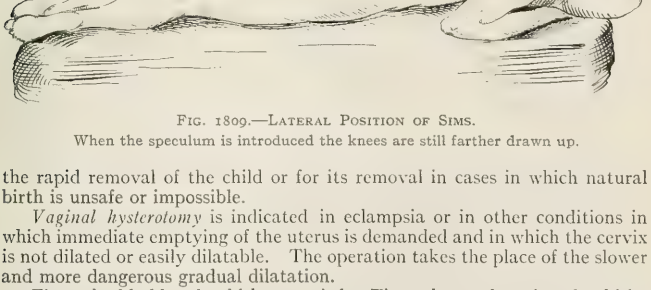


FIG. 1809.—LATERAL POSITION OF SIMS.
When the speculum is introduced the knees are still farther drawn up.

the rapid removal of the child or for its removal in cases in which natural birth is unsafe or impossible.

Vaginal hysterotomy is indicated in eclampsia or in other conditions in which immediate emptying of the uterus is demanded and in which the cervix is not dilated or easily dilatable. The operation takes the place of the slower and more dangerous gradual dilatation.

First, the bladder should be emptied. The vulva and vagina should be dilated by the gloved hand up to a size to permit the passage of the child.

If the vagina is small it will be necessary to make two posterolateral incisions. The perineum is then retracted strongly and the uterus drawn down by tenacula on either side of the cervix. If the cervix cannot be drawn down well into view the operation should not be attempted. A transverse incision

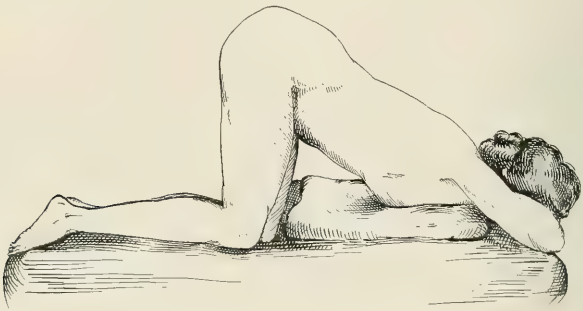


Fig. 1810.—Knee-chest Position.

is made at the anterior vaginocervical angle, and the bladder separated from the uterus by blunt dissection.

A retractor is introduced between the bladder and uterus and the bladder retracted forward. The cervix and lower segment of the uterus are then

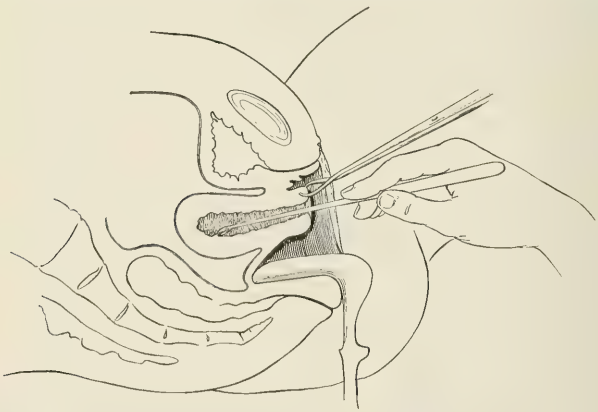


Fig. 1811.—Dilatation and Curettage of Uterus.
The cervix has been grasped with tenaculum forceps; the uterine canal has been dilated; the curet is seen in operation.

split in the median line by strong scissors (Fig. 1812) for about 9 cm. (3½ inches). If this is carefully done the membranes should not be ruptured in cases of pregnancy

If the operation is done after the eighth month of pregnancy, a median incision of the posterior cervical wall should also be made. This should be preceded by a transverse incision across the posterior fornix, and an upward displacement of the peritoneum. The volsella should be removed. Extraction of the child is best done by version and pulling down the feet. Forceps should be at hand for use on the head. After delivery the uterus and the mucous membrane are sutured separately with chromic catgut.

In eclampsia in a primipara, abdominal hysterotomy requires less time and is more favorable for the child, even in cases in which the head is engaged.

Vaginal hysterotomy for nonobstetric conditions, is a simple operation and is commonly called for in the treatment of polypus, submucous fibroid,

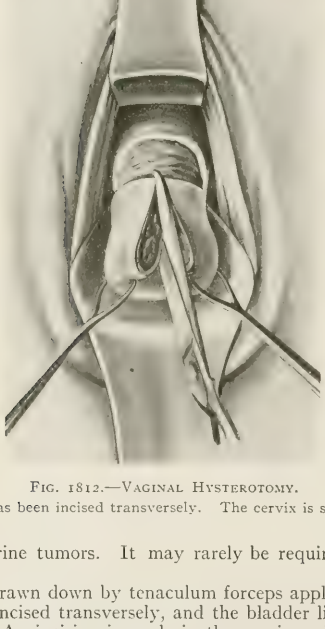


FIG. 1812.—VAGINAL HYSTEROTOMY.
The anterior fornix has been incised transversely. The cervix is split in the median line

or other intra-uterine tumors. It may rarely be required for the removal of foreign body.

The cervix is drawn down by tenaculum forceps applied laterally. The anterior fornix is incised transversely, and the bladder lifted forward away from the uterus. An incision is made in the cervix, splitting the anterior wall in the median line as far up as the internal os. This gives an opportunity for inspection of the interior of the uterus. If further exposure of the interior is necessary, the cervix may either be drawn down still further, or it may be pressed back into the posterior fornix and the fundus tilted forward. The disease for which the operation is done being discovered, the incision is extended as high as necessary. If desired the uterus may be tilted forward

far enough to divide the vesico-uterine fold of peritoneum, and the incision of the uterus carried on through the fundus.

In suturing the wound in the uterus, the knots of the sutures passed through the peritoneum should be tied inside of the uterus rather than on the peritoneum. The other sutures should be tied outside. One layer of interrupted sutures suffices to close the wound (Fig. 1813). After sewing the uterus and cervix the fornix is sutured (Fig. 1814).

This operation has much to recommend it in preference to the curet for diagnostic purposes. If carcinoma is present, it is discovered to the eye and can be dealt with immediately. It is a very simple matter to proceed with the operation as a vaginal hysterectomy. The cervix may be saved by amputating above it.

Abdominal hysterotomy for nonobstetric conditions is done for the same purposes as the vaginal operation. The uterus is exposed by a suprapubic incision, lifted up with a tenaculum grasping the fundus, packed off with

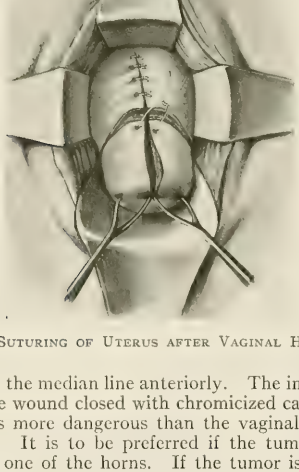


FIG. 1813.—SUTURING OF UTERUS AFTER VAGINAL HYSTEROTOMY

gauze, and incised in the median line anteriorly. The intra-uterine condition is dealt with and the wound closed with chromicized catgut.

This operation is more dangerous than the vaginal operation if uterine infection is present. It is to be preferred if the tumor to be removed is at the fundus or in one of the horns. If the tumor is lower in the uterus the vaginal operation is better. The surgeon must apply his judgment to the individual case in determining which operation to perform.

Cesarean section (obstetric abdominal hysterotomy) is for the delivery of the child through an abdominal and uterine incision. The operation is *indicated* in cases in which there is a living child and some condition, either of the mother or child, which in the event of labor will imperil the life of either. The operation is done (1) when obstruction prevents engagement of the head, and (2) when rapid delivery is necessary and it cannot be accomplished by the vagina.

The usual obstructing conditions are: (1) deformed pelvis, (2) tumor,

(3) large head, (4) abnormal position which cannot be corrected, (5) rigid and high cervix, and (6) atresia of the genital outlet. The operation is indicated when the true conjugate is less than 8 cm. ($3\frac{1}{8}$ inches). When the conjugata vera is less than 10 cm. (4 inches) some special expedient must be resorted to. Both high forceps and version are now regarded as being no less dangerous than hysterotomy.

Tumors, causing obstruction, can often be manipulated out of the way with the patient in the knee-chest position. If this cannot be done the tumor may be removed. If the tumor cannot be isolated, complete or partial removal of the uterus may be done in connection with Cesarean section.

The conditions requiring rapid delivery by Cesarean section when the head does not engage are (1) eclampsia, (2) placenta previa with rigid cervix, (3) hemorrhage due to detachment of placenta, (4) serious exhaustion of patient, and (5) death of the mother.

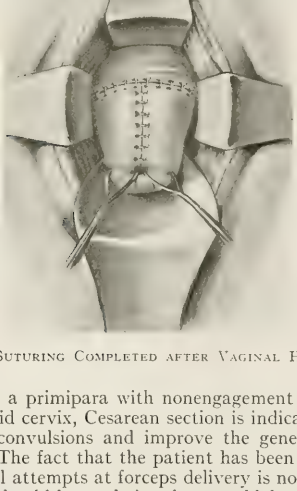


FIG. 1814.—SUTURING COMPLETED AFTER VAGINAL HYSTEROTOMY.

In eclampsia, in a primipara with nonengagement of the head, or in a multipara with a rigid cervix, Cesarean section is indicated if medical treatment fails to stop convulsions and improve the general condition within one or two hours. The fact that the patient has been in labor a long time and had unsuccessful attempts at forceps delivery is no contraindication.

All *preparations* should be made in advance of labor. The best time for operation is when labor has begun and dilated the cervix enough to admit two fingers. This dilatation is desirable for drainage. If that much dilatation is not present it should be produced artificially before the operation is finished.

The general preparation should be the same as that for abdominal section and pelvic operation combined; bowels emptied by laxative and enema; vaginal douche; pubic hair removed; skin cleansed. For emergency purposes, the forearm in the region of the elbow should be cleansed and covered with an aseptic dressing, ready for venous infusion.

The *instruments* required are: scalpels; blunt scissors; two double ten-

acula; long sponge forceps; hemostatic clamps; twelve curved needles, No. 1, each threaded with a No. 2 chromic catgut suture, for suturing the uterus; for suturing the abdominal wall, curved needles threaded with No. 1 chromic catgut; a piece of rubber tubing for aspirating mucus from the mouth of the child should be at hand; apparatus for intravenous infusion; and a hypodermic syringe with ergot. If the surgeon has skill in local anesthesia, infiltration of the abdominal wall with 1 : 200 novocain is to be preferred, as local anesthesia gives the child a better chance than general anesthesia. When the latter is used, ether anesthesia is to be preferred to chloroform. The abdomen should be surrounded by sterile coverings.

The *operation is begun* by a skin incision 18 cm. (7 inches) long, near the median line. About three-fourths of the incision should be above the umbilicus. The abdominal wall is very thin and the division of the peritoneum

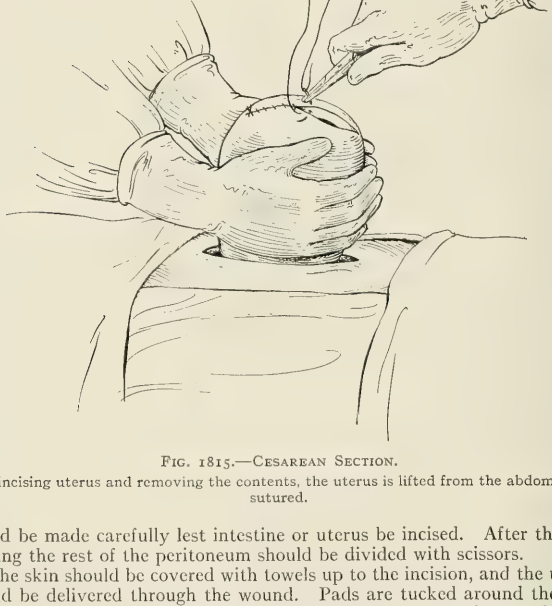


FIG. 1815.—CESAREAN SECTION.
After incising uterus and removing the contents, the uterus is lifted from the abdomen and sutured.

should be made carefully lest intestine or uterus be incised. After the first opening the rest of the peritoneum should be divided with scissors.

The skin should be covered with towels up to the incision, and the uterus should be delivered through the wound. Pads are tucked around the base of the uterus to exclude fluid from the abdomen. An assistant places a hand on each side to steady the uterus and to control the broad ligaments in the event of hemorrhage (Fig. 1815).

An incision 10 or 13 cm. (4 or 5 inches) long, is made in the median line in the anterior wall of the uterus. The uterus is thin—2 to 4 mm. ($\frac{1}{16}$ to $\frac{1}{4}$ inch)—and care should be taken not to cut the baby. If the placenta is in the way it should rapidly be cut through.

As soon as possible after the uterus is opened the child should be removed. This should be done by lifting on the head and legs at the same time. If the child is delivered wholly by traction on the legs or buttock there is danger of aspiration asphyxia. The surgeon should pass one hand down the back to the occiput and dislodge it by flexion. The cord should be clamped and divided and the child delivered over to an obstetrician for resuscitation. (The sooner fluid and mucus are removed from the child's mouth and throat and artificial respiration is begun the better are its chances of living.) A hypodermic injection of ergot should be given the mother. The placenta is next grasped and gently twisted from its attachment. All of the membranes should come with it.

The surgeon then applies a tenaculum at each extremity of the wound in the uterus. The assistant who has held the broad ligaments now takes these two tenacula and gently supports the womb. The slight traction incident to lifting it up usually suffices to control bleeding. The interior of the uterus is sponged dry. Any local bleeding should be checked by pressure.

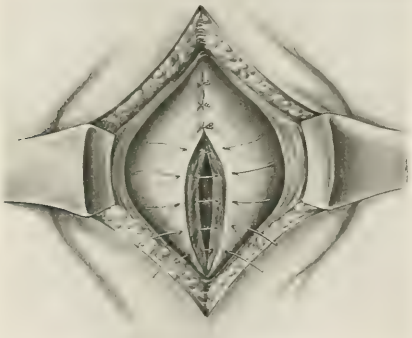


FIG. 1816.—CESAREAN SECTION.
Closure of wound. Showing application of sutures within the abdomen.

If there is no oozing from the inside of the uterus, and the uterus is contracting, no packing is needed. If there is some oozing which is controlled by light pressure, a strip of gauze 15 cm. (6 inches) wide and 1 or 2 meters (1 or 2 yards) long may be packed in the uterus with one end knotted and carried down into the vagina.

The incision in the uterus should be closed with interrupted sutures of No. 2 chromic catgut, which should be placed 1.25 cm. (½ inch) from the edge of the wound and 2.5 cm. (1 inch) apart. The sutures should include all of the layers of the uterus except the mucous membrane. These sutures will check most of the bleeding from the incision. Before the last two sutures are tied a hot towel should be applied to the uterus and any blood which has accumulated squeezed out. This also causes the uterus to contract. A running suture of the same material, embracing peritoneum and the superficial fibers of the muscular coat, is then applied over and between the interrupted sutures (Fig. 1816).

The abdomen should be cleansed of blood or amniotic fluid which should have been excluded by careful protection. The omentum is brought down behind the uterus. The peritoneum and transversalis fascia are sewed. The muscles should be brought together and loosely sewed. If there is much muscular separation, the gap should be closed by overlapping the fascia. Over this the superficial fascia and skin are united in separate layers (see Closure of Abdomen, Vol. II, page 516).

The *after-treatment* is not different from that of any obstetric and abdominal case. The uterine packing should not be left in more than twelve or twenty-four hours.

Operation, with *retention of the uterus in the abdomen* until delivery of the child, is preferred by some surgeons. The assistant makes lateral pressure through the abdominal wall. A 13-cm. (5-inch) incision is made below the umbilicus. The uterus is incised in the same line and the child delivered. As soon as the child is removed the uterus is drawn out of the abdomen and the placenta removed. It is caught with tenacula at the ends of the wound and the operation then proceeded with as above described.

At the New York Lying-In Hospital, most excellent results have been secured by making a small incision above the umbilicus for access to the uterus. The child is delivered without removing the uterus from the abdomen. Delivery is accomplished with but little loss of blood, which is prevented by the traction in bringing out the child. There is less shock than when the uterus is outside of the abdomen. When the uterine wound is sutured, the wound lies below the abdominal wound and adhesion between the uterus and abdominal wall is less apt to occur.

Extraperitoneal Cesarean section may be done in the presence of uterine infection. B. C. Hirst (Surg., Gyn. and Obst., xvii, 1913) advocated it as a routine measure. A low median incision is made down to the symphysis. The parietal peritoneum is opened as usual. The peritoneum on the front of the uterus is incised in the same line, pressed aside, and the edges of the two peritoneal layers sewed together in such a manner as to exclude the general peritoneal cavity from the area of the uterus in which the Cesarean incision is to be made (Fig. 1816a).

Postmortem Cesarean section is done to save a child whose mother has expired. The longest interval between the death of the mother and the delivery of a living child has been seven minutes. The earlier the child is removed from the dead mother the better are its chances of surviving.

The results of Cesarean section in experienced hands show about 1 per cent. of mortality to both mother and child. The uterus is not damaged and future pregnancies are not interfered with. The operation may be repeated several times on the same woman.

Low hysterotomy (suprapubic cervical Cesarean section) is the operation devised by Pfannenstiel whereby the uterus is not removed from the abdomen and artificial detachment of the placenta is not necessary. A 15-cm. (6-inch) transverse incision is made across the lower abdomen at the level of the anterior superior iliac spines. This passes through the skin, superficial fascia and aponeurosis down to the muscle. These structures are dissected upward and downward uncovering the muscle from the umbilicus to the pubes. The peritoneum is then opened vertically in the middle line by an incision 10 cm. (4 inches) long. Next the peritoneum at the vesico-uterine reflection is opened and the vagina exposed. If the vesico-uterine reflection is high a transverse incision may be made, and the bladder separated. If the operation is done when the cervix has dilated, the bladder lies against the vagina and the latter need not be exposed. A median vertical incision

is made in the cervix 10 or 13 cm. (4 or 5 inches) long and the child delivered quite naturally. The placenta is delivered by external pressure. The uterine wound is sewed in two layers as described for the high operation. The abdominal wound is closed as usual.

Symphysiotomy is an operation for increasing the size of the parturient canal, and is to be followed by delivery by version or with forceps. It may usually be done in cases in which the true conjugate is between 7 and 9 cm. ($2\frac{3}{4}$ and $3\frac{1}{2}$ inches). In cases with a true conjugate of less than 7 cm. ($2\frac{3}{4}$ inches) it is not to be preferred to Cesarean section. It is sometimes em-

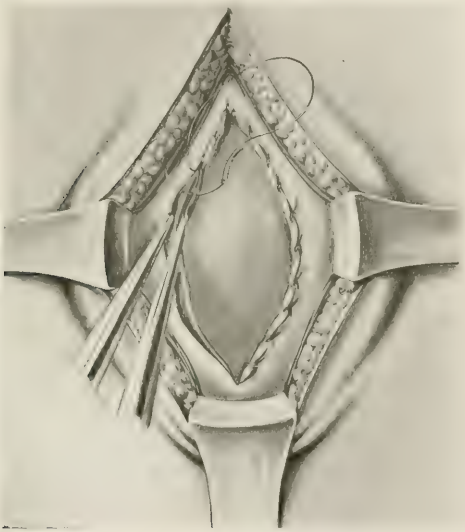


FIG. 1816a.—EXTRAPERITONEAL CESAREAN SECTION.

The parietal and uterine peritoneum have been incised and the edges of the two layers of peritoneum are in process of being sewed together. The body of the uterus is seen presenting in the wound. By this means the peritoneal cavity is excluded from the field of operation.

ployed in the border-line cases which cannot be delivered after a fair test of labor either with or without forceps. This is in the cases with a conjugate of 8 to 10 cm. ($3\frac{1}{8}$ to 4 inches).

The *operation* must be done with the utmost regard for asepsis. By the open method an incision is made in the *median line* about 8 cm. (3 inches) long in front of the symphysis pubis. The insertion of the recti muscles is partly divided to permit the passage of a protecting retractor behind the symphysis. The pubic ligaments are divided with a knife. The separation may be increased by flexing the thighs and then carefully abducting them. The subpubic ligament is divided last. A temporary dressing is applied and the labor completed.

Some surgeons prefer a short *transverse incision* just above the pubes. Through this a narrow bistoury is passed down behind the symphysis and the ligaments divided from behind forward. The urethra and bladder have been wounded by this operation.

Symphyseotomy has been followed by many and dire complications. The maternal and infant mortality are much higher than in Cesarean section.

Hebosteotomy (hebotomy, pubotomy) was devised to avoid the dangers of symphyseotomy. The operation is done through the pubic bone. Its indications are the same. There is less risk of injury to the bladder, urethra, and the crura; and there is less danger of non-union. The *open method* of operation may be used. The *subcutaneous method* offers no especial advantages.

For the subcutaneous method a large, blunt, half-curved ligature carrier is used. It should represent the half of a circle 6.3 cm. (2½ inches) in diameter. A short horizontal incision is made just above the pubic bone on the left side, opposite the spine of the pubes. Blunt dissection opens up the wound a short distance behind the bone. The needle is passed close to the bone and caused to emerge at its lower border just external to the labium majus. The skin is incised and the needle brought to view. The needle may be guided by a finger in the vagina. The carrier is threaded with strong silk which carries a wire saw back through the wound.

In some cases it seems best to do the operation early and allow labor to progress; in other cases the operation is done after tests of labor have shown that delivery is impossible through the natural passage. Some surgeons pass the silk carrier, test labor with forceps, and then proceed with the saw if the forceps fail. The bone is sawed through with as little damage to the skin as possible. After delivery the patient is treated as for fracture of the pelvis. A broad adhesive strip around the pelvis and rest in bed are the important requisites.

The operation has a mortality greater than Cesarean section. In both of the above operations one of the dangers is the sudden separation of the bones as soon as they are divided. This should be prevented by keeping the knees together and only allowing abduction gradually.

The open operation is done through an incision about 10 cm. (4 inches) long, extending from just internal to the spine of the pubes, downward nearly parallel with the left labium majus. The bone is exposed and vessels clamped. The bone is divided just internal to the pubic spine by means of the wire saw, the wound packed with gauze, and delivery accomplished. If satisfactory hemostasis has been secured the packing may be removed and the wound may be sutured. If oozing is going on the wound should be sutured over a gauze packing. A drain should emerge at the lower end of the wound.

Hysterectomy.—Removal of the uterus, either partially or completely, may be done through the abdomen or vagina. The operation is done for carcinoma, sarcoma, and other malignant diseases; for fibromyoma which involves so much of the uterus that it cannot be excised; for inflammatory and degenerative conditions, prolapse, inversion, and fistula which cannot otherwise be cured.

The vaginal operation is less dangerous, causes less discomfort to the patient, has a shorter convalescence, and obviates the danger of ventral hernia. It requires that the vagina be roomy enough for the manipulations, that the uterus be not too large, and that the uterus be movable and free from adhesions and capable of being drawn down into the vagina.

The suprapubic operation is to be preferred in cases in which the uterus or

its tumor are large, or adherent, or the vagina long and narrow, and in cases in which dissections of tissue external to the uterus are necessary.

The *preparation* of the patient for either operation should be the same as for abdominal section and vaginal operation combined (see Vol. II, page 499 and page 333).

The operation should be so conducted that the *ovaries* are not removed unless there is specific indication for their removal.

Vaginal hysterectomy requires the general preparation of the patient employed for both abdominal and vaginal operations. At the final cleansing of the vagina, if the cervix is the seat of cancer, ulcerating or necrotic tissue should be scraped away, shreds cut off, the underlying tissue sterilized with phenol or iodin, and the raw surface covered over by the surrounding sound tissue held with a few silk sutures or tenaculum forceps.

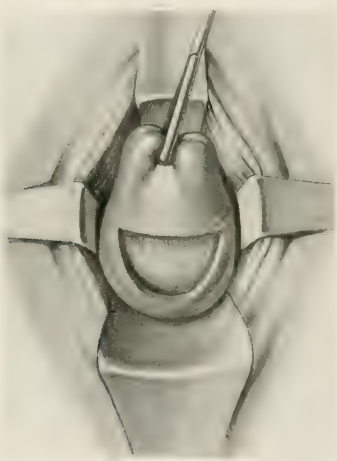


FIG. 1817.—VAGINAL HYSTERECTOMY (FIRST STAGE).
Peritoneum of culdesac exposed by transverse incision in posterior fornix of vagina.

The *instruments* necessary are four long vaginal retractors, four double tenacula, four long clamps, long scissors (curved and straight), ten hemostats, ligature carrier, needle forceps, long tissue forceps, curved needles, chromic catgut, silk sutures, and gauze packing.

The *operation* requires the patient in the vaginal position, knees and hips flexed, pelvis elevated, and a good light at the surgeon's back. The vagina should be widely retracted. This is best done by a weighted perineal retractor and two lateral retractors or with a large three-bladed vaginal speculum. The cervical canal should be cleansed and sterilized. If there is discharge the os should be closed with silk sutures, and the ends left long for traction purposes. Sponging should be done with sponges on handles.

If no sutures are applied to the cervix it should be grasped with tenaculum forceps catching both sides of the canal. An incision, representing half of a circle, should be made around the cervix posteriorly. This incision should

pass through the vaginal wall. Blunt dissection soon exposes the peritoneum of the cul-de-sac (Fig. 1817). The incision is then continued around in front of the cervix, the vesico-uterine space entered, and the bladder separated from the uterus by blunt dissection with the index finger. In operating for fibromyoma the dissection should keep close to the uterus; in operating for cancer it should keep away from the uterus.

This blunt dissection is carried posteriorly and anteriorly as far as the peritoneum, but not laterally where the vessels enter the uterus. The posterior retractor is then slipped into the posterior wound, the peritoneum held lightly with forceps and cut with scissors. By passing in two fingers, this opening is enlarged laterally as far as the broad ligaments. A gauze pad is placed in this opening to prevent intestines coming down. The anterior

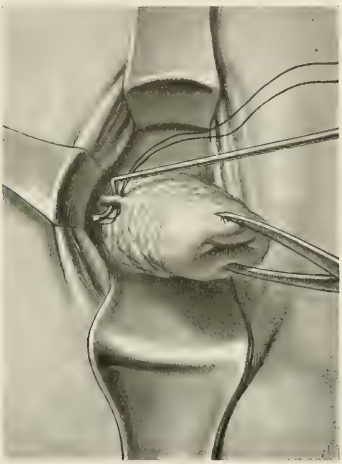


FIG. 1818.—VAGINAL HYSTERECTOMY (SECOND STAGE).
Passing ligature about uterine artery.

space is then entered, the peritoneum of the vesico-uterine fold cut, and the opening enlarged with the fingers. The peritoneal cavity is now opened behind and in front and the uterus is attached only by the broad ligaments at the sides.

The retractors are now shifted to one side to expose the broad ligament while the tenaculum draws the cervix downward and to the other side. The left index finger is passed in the posterior opening behind the broad ligament to serve as a guide. A round-pointed ligature carrier, armed with No. 2 chromic catgut, is passed from before backward and from above downward, about 1 cm. ($\frac{3}{8}$ inch) from the uterus and including about 1 cm. of tissue (Fig. 1818). Three or four such ligatures are required on each side to tie off the broad ligament. As each one is tied its ends are cut short and the tissue bundle which it controls cut about 3.3 mm. ($\frac{1}{8}$ inch) from the uterus. It is obvious that every time this tissue is cut it will bleed from the uterine side so

long as the uterus has any blood supply. This is prevented by applying also a silk ligature close to the uterus on every mass of tissue and cutting between the ligatures, or by applying a clamp. The former is to be preferred unless the vagina is very roomy. In cutting between the two ligatures or between the ligature and the clamp, enough tissue should be left so that the distal ligature cannot slip off, and the tissue should not be divided higher than it is ligated.

Two or three ligatures can thus be tied on one side before doing the same on the other side. The vessels of the cervix are generally included in the second ligature, and the uterine vessels in the third. It is well to identify the uterine artery by touch before tying it, as the surgeon feels more secure if he knows just when he is dealing with this important structure. Care should

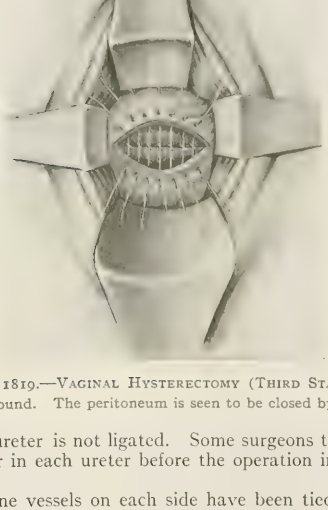


FIG. 1819.—VAGINAL HYSTERECTOMY (THIRD STAGE).
Suturing of vaginal wound. The peritoneum is seen to be closed by a continuous suture.

be taken that a ureter is not ligated. Some surgeons take the precaution to place a catheter in each ureter before the operation in order to identify them.

After the uterine vessels on each side have been tied, a finger may be hooked over the broad ligament on one side and the uterus brought down through the vagina and a ligature applied at each cornu. Or the uterus may be rotated forward by grasping the fundus with tenacula, and the fundus delivered through the vagina while the cervix swings backward toward the abdomen, and the last ligatures are tied at the cornua. The ovaries are left in the abdomen attached to the broad ligaments.

The uterus being removed, retractors are placed to retract in all four directions. Blood is sponged away, and the line of ligatures on each broad ligament is inspected to ascertain whether bleeding is present. This is most important, as it often happens that a ligature is pulled off during the manipulations. The surgeon should be satisfied only with absolute hemostasis in this region. It is because of the danger of the dislodging of ligatures that

some surgeons use silk only on the broad ligament. It should be employed always by the surgeon who has not had large experience. Next attention should be given to the edges of the vagina. Any further bleeding should be controlled by ligatures or over-and-over sutures. The cut edge of the vesico-uterine fold of peritoneum should be caught and sutured to the edge of the recto-uterine fold. The vaginal edges may be sewed together leaving an opening in the middle for the drain (Fig. 1819). A strip of gauze should be placed just through the vaginal opening against the raw surfaces of the broad ligament. This should be brought out through the vagina, and some additional packing placed in the latter.

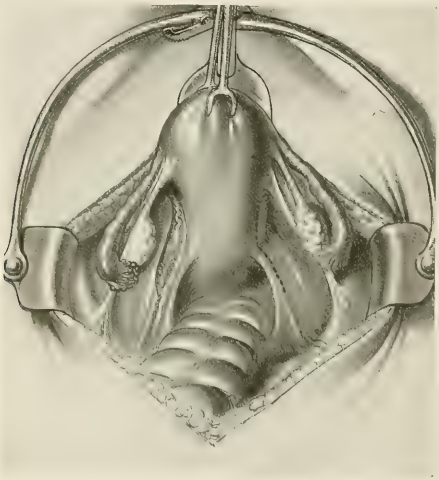


FIG. 1820.—ABDOMINAL HYSTERECTOMY (FIRST STAGE).
The uterus is drawn forward and downward against the pubes and the peritoneum is incised to expose the ureters and uterine vessels.

It is good surgery and the procedure of choice if haste is desirable, to omit suture of the peritoneum and vagina. In such an event a gauze drain is passed just through the upper vaginal orifice and a snug gauze packing left in the vagina. Some surgeons unite the peritoneum in the middle by only one or two stitches.

Vaginal hysterectomy by morcellement is done for benign tumors, demanding hysterectomy, which are too large to be delivered through the vagina in cases in which abdominal hysterectomy is not indicated. The operation is started and carried out as far as possible like the above, but when a point is reached where the operation must stop because the uterus cannot be brought down any further, the cervix and the interior of the tumor are cut out and removed. Piece by piece the inside of the tumor is grasped by forceps and cut out with long scissors until the tumor is so reduced that the operation can proceed as a typical hysterectomy.

Vaginal hysterectomy with clamps is done in cases in which on account of

the small size of the vagina, necessity for haste, or some other reason, the uterine vessels cannot be tied. In such cases the vessels are caught with long artery clamps and the latter left in place. The clamps should be packed about with gauze, and the handle of each should be tied with a silk thread to prevent its becoming unlocked. They may be removed very carefully at the end of forty-eight hours, the gauze not being disturbed. The gauze should be left for about five days.

Abdominal hysterectomy is begun the same as vaginal hysterectomy. The uterine canal is sterilized, and the os closed with silk sutures to prevent soiling of the peritoneum. The incisions around the cervix through the fornices are made, and the dissection carried as far as the peritoneum in front of and

FIG. 1821.—ABDOMINAL HYSTERECTOMY (SECOND STAGE).
The uterine artery has been divided, the broad ligament cut, and the uterovesical connections separated.

behind the uterus. The folds of peritoneum are not opened. One or two ligatures are applied on either side to the lower part of the broad ligament (see Vaginal Hysterectomy above). The vagina is then packed with gauze, the patient placed recumbent on the table and the abdominal operation proceeded with.

The abdomen is opened by a median incision extending from the umbilicus to the pubes. It may be extended above the navel if the size of the tumor demands it. The patient is then tilted into the lowered head position (Trendelenburg) and the intestines and omentum retracted and held up with protective pads. Adhesions are separated (see Peritoneal Adhesions, Vol. II, pages 520 and 599).

The fundus of the uterus is grasped with volsellum forceps, drawn forward and the protective pad passed into the cul-de-sac. An assistant hold-

ing the forceps draws the uterus to one side and downward. The surgeon grasps the broad ligament on either side, internal or external to the ovary, depending upon whether it is to be removed or left. With a knife or curved scissors having a probe point the posterior layer of the peritoneum is divided on either side to make an opening at the side of the uterus for exposure of the ureter and uterine vessels (Fig. 1820). The peritoneum is pressed back from the incision and the ovarian and uterine vessels exposed. The ureter should be identified. The uterine artery and veins are tied separately after passing the ligatures under them with a needle. As the vessels are tied, they are divided internal to the ligature. A clamp is put on the uterine side. The ligatures are cut short. The ovarian artery and vein are tied if the ovary is to be removed.

Fig. 1822.—Abdominal Hysterectomy (Third Stage).

The vessels have been tied and the broad ligament divided. The uterus is drawn downward. The dotted line indicates the posterior incision which is to open the posterior fornix of the vagina.

In case of carcinoma the ligature should be placed well out on the pelvic wall. In case of myoma the vessels may be ligated close to the uterus. In the latter case the vessels of the cervix will be ligated; in the former case the uterine vessels will be tied external to the place where the vessels of the cervix join the uterine vessels. In cases of tumor of the uterus, varicose veins of the broad ligament may require multiple ligatures. The vessels may be tied in two places and cut between or a clamp placed on the uterine side. The ureter should be identified and protected. The peritoneum should be divided between the uterus and bladder and the uterus dissected free from the latter (Fig. 1821).

The same operation is done on the other side and the vessels tied and

divided. Then the broad ligament is cut through. It is in this step when operating for cancer that the dissection should keep as far from the uterus as possible. The layers of peritoneum of the broad ligament are divided with scissors. The round ligament is cut through. The uterus is drawn downward (Fig. 1822). The peritoneum of the posterior surface of the uterus is divided across and pressed downward; and the uterus is removed.

It will be noted in this operation, which has been preceded by division of the vaginal fornices, that when the peritoneum of the vesico-uterine fold and of the recto-uterine pouch is divided the vagina is opened, and the gauze which was packed in from below, appears in the wound.

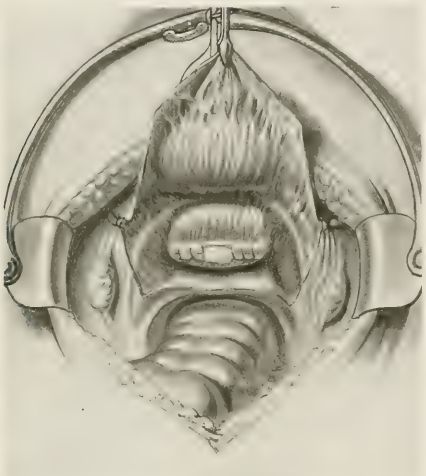


FIG. 1823.—ABDOMINAL HYSTERECTOMY (FOURTH STAGE).
Showing wound after removal of uterus. The vagina is closed by suture except for drainage opening. The ovaries are saved.

The upper end in the vagina should then be partly closed by sutures at either side, leaving an opening in the middle for drainage of the subperitoneal space (Fig. 1823). One of the sutures on either side which closes the vagina should catch the broad ligament above to hold up the vagina and prevent its prolapse. A drain, enveloped in rubber protective to prevent adhesion, should be passed into the vagina through the drain opening as the gauze packing is drawn out of the vagina below. The peritoneal opening is then closed, with a continuous suture of fine catgut, catching the cut edges, and shutting off the pelvic wounds from the peritoneal cavity (Fig. 1824). The toilet of the peritoneum is then made, and the anterior abdominal wound closed. The drain emerges at the introitus.

In cases in which the uterus lies very high or the cervix is not easily reached through the vagina, the preliminary vaginal operation should be omitted. As a preliminary to all operations for hysterectomy the vagina

should be cleansed. If the fornices are packed with gauze, their opening from above is facilitated. In such cases the fornices of the vagina should be opened from above after the uterine vessels have been tied. This circumcision is done with curved scissors, the cut edges of the vagina being caught with clamps to prevent retraction. Immediate suture of the vagina controls bleeding.

Partial abdominal hysterectomy, or supracervical amputation of the uterus, is not preceded by any vaginal incisions. The abdominal operation is proceeded with just as for abdominal hysterectomy as far as the cervix. The peritoneum is divided and all of the vessels are ligated down as far as the cervix. Instead of dissecting the bladder from the cervix and opening the fornices, the uterus is amputated transversely at the cervix (Fig. 1825).

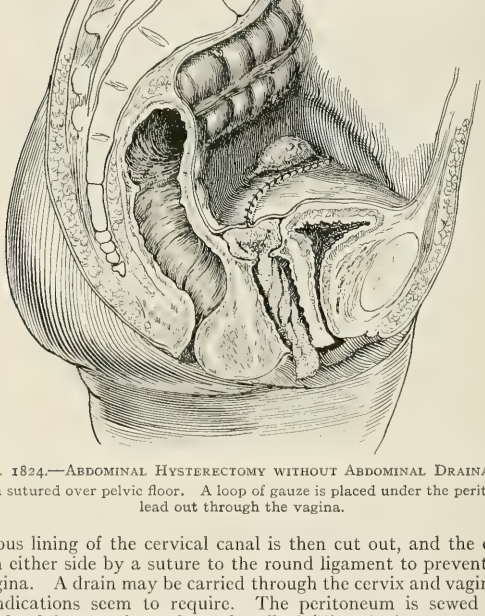


Fig. 1824.—Abdominal Hysterectomy without Abdominal Drainage. Peritoneum sutured over pelvic floor. A loop of gauze is placed under the peritoneum and lead out through the vagina.

The mucous lining of the cervical canal is then cut out, and the cervix attached on either side by a suture to the round ligament to prevent prolapse of the vagina. A drain may be carried through the cervix and vagina, or not, as the indications seem to require. The peritoneum is sewed over the stump and pelvic wounds as above described (Fig. 1826).

This operation requires less time than complete hysterectomy, and is to be preferred in cases in which the cervix does not participate in the disease for which the operation is done.

Partial hysterectomy for fibroid tumors requires that the mass should be grasped at the fundus with heavy tenaculum forceps and lifted out through the abdominal wound after adhesions have been freed. If the mass is large,

the typical operation as described above, cannot easily be done. The uterus should be drawn to one side and a long clamp placed on the broad ligament close to the uterus. A ligature of catgut should be passed through

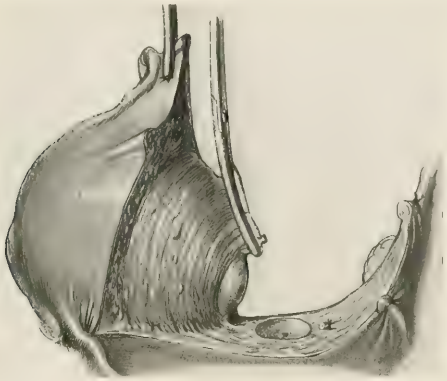


FIG. 1825.—PARTIAL ABDOMINAL HYSTERECTOMY FOR MYOMA.
All of the structures of one broad ligament are seen divided, the cervix amputated, and the uterus tilted to the opposite side.

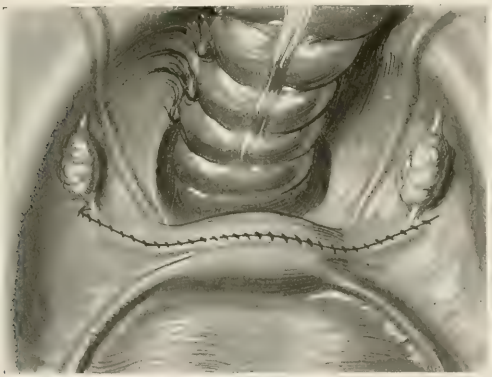


FIG. 1826.—PARTIAL ABDOMINAL HYSTERECTOMY.
The cervix has been sutured; the round ligament is fastened to the cervix; and the peritoneum sewed over all.

the upper part of the broad ligament about 1 cm. ($\frac{3}{8}$ inch) external to the clamp. A second ligature should be placed below this. These mass ligatures should be continued and the broad ligament cut close outside of the clamp

as far as the uterine artery. An incision anteriorly downward through the peritoneum should expose the uterine artery. It is best to tie the artery separately without including peritoneum in the ligature. It should be tied in two places and cut between.

The same procedure is carried out on the opposite broad ligament. An incision through the peritoneum is then made in front of the uterus just above the bladder. This incision should connect the lower ends of the incisions of the broad ligaments. Large veins are ligated and divided, a clamp being placed on the uterine side. The bladder is separated from the uterus by blunt dissection. In some cases the uterine arteries are best discovered after this dissection is made. The cervix is then cut across as in *partial hysterectomy,* the posterior layer of peritoneum divided behind the uterus, and the mass removed.

Any remaining bleeding vessels are looked for and tied. The mucosa of the cervical canal is cut out, and a drain passed through the cervix. The cut edges of peritoneum are then united by a running suture, covering in all raw surfaces and shutting off the peritoneal cavity from the pelvic wounds.

Panhysterectomy for fibroid tumor may be done as is described above for typical abdominal hysterectomy, either with or without preliminary vaginal incision. In many cases the cervix cannot be drawn down sufficiently to allow the vaginal work to be done. The experienced surgeon recognizes these cases and proceeds wholly through the abdomen. The tumor is drawn out through the abdominal wound and the operation conducted as for partial hysterectomy as far as the amputation of the uterus. Instead of amputating at the cervix the anterior fornix is opened by carrying the dissection down in front of the cervix. The lateral vessels of the cervix are tied, the posterior fornix cut through, and the whole uterus removed. The wounds are treated as for typical abdominal hysterectomy.

In other cases the whole tumor mass may be brought out of the abdomen and drawn down over the pubes. The intestines are held upward. A pair of forceps introduced into the vagina makes prominent the posterior fornix of the vagina. This is incised in the cul-de-sac. The vaginal portion of the cervix is grasped with tenaculum and drawn through the wound. The incision in the vagina is then carried around the cervix, which is drawn backward and the bladder separated from the uterus. This exposes the uterine vessels which are clamped as they are brought into view. The cervix is pulled backward and upward and the division of broad ligaments, and vesico-uterine fold of peritoneum completed. The further treatment is as for typical abdominal hysterectomy.

In other cases the uterus may be drawn upward and dissected free from the bladder through an incision at the vesico-uterine juncture. The anterior fornix of the vagina is then opened and the cervix brought forward through the wound. The uterine artery is ligated, and the operation proceeded with as above.

In some cases, adhesions, inflammatory infiltration, the peculiar form of the tumor, or the presence of accessory fibroids in the broad ligaments make any of the above operations difficult. In such cases *splitting the uterus* in the median line and removing each half separately may be practised. The uterus should first be separated as much as possible from bladder and intestines. The regions of the cornua are grasped by heavy forceps. The rest of the abdomen should be well protected. The uterus is then incised in an anteroposterior direction and the two halves drawn forward and separated. A heavy clamp is placed on each half near the cut surface, and the first forceps removed. The bisection is continued down to the cervix—or through

the cervix if necessary—the cut edges being grasped by heavy clamps as the operation proceeds. One-half of the uterus is then divided from the cervix or vagina by transverse incision. It is lifted upward and outward and the uterine artery and veins tied. The broad ligament is divided from below upward until half of the uterus is detached and removed. The other half is treated in the same manner.

This operation is of especial value in cases of fibroids lying between the folds of the broad ligaments. It permits their removal *internally* and with less danger of injury to the ureters.

Hysterectomy by two suture-ligatures was devised and perfected by R. L. Dickinson (Jour. Obst. and Gyn., British Emp., September, 1913). A continuous suture is used. It grasps the tissues which ordinarily are grasped by separate sutures. Enough tissue should be caught to prevent the suture slipping or tearing out. The suture is used double. The first bite circles the round ligament; the second controls the ovarian vessels. If varicose veins are present in the broad ligament they are included in the third sweep of the needle. As the tissues are cut between the suture and the uterus the suture is used as a retractor as well. The uterine artery is embraced in the next turn, which for security should catch some cervical or vaginal tissue. The ends are tied. The same is done on the opposite side, and the ends used to complete the suspension of the cervix, the suturing of the peritoneum, or whatever concluding steps are required.

Abdominal hysterectomy for carcinoma should be kept as far from the uterus as is possible, to avoid carcinomatous tissue. The incision around the upper end of the vagina should be well away from the cervix. The vaginal incision should be made only in cases in which there is a strong probability that the disease is localized in the uterus.

If the cervix is the seat of broken-down carcinoma, it should be curetted down to solid tissue, and then the sound surrounding tissue sewed over the excavation made by the curet. This is done to prevent infection. After this the vagina should be washed out, and the diseased region painted with iodin. The vaginal incision may then be made. The actual cautery may be used to supplement the curet.

If the patient has lost blood, is anemic, and septic from the ulcerating disease, it is often best to remove the necrotic tissue and burn down to sound tissue with the actual cautery a week or ten days before attempting hysterectomy. This may be done under nitrous oxid.

Many surgeons now rapidly curet the soft mass at the cervix, wash out the vagina, deeply cauterize the base of the curetted excavation, pack the cavity with gauze, and then proceed with the suprapubic operation.

The patient should be placed in the lowered-head position (Trendelenburg) and the abdomen opened. The extent of the disease should be examined for, the broad ligaments palpated, glands along the iliac vessels and in the uterosacral ligaments should be sought, and the liver inspected. If ineradicable metastases are found, the abdomen should be closed. If there are only found some questionable lymph nodules outside of the hysterectomy zone, or if no sign of metastasis is discovered, hysterectomy should be done.

The intestines should be retracted and well protected to give a clear field for operation. The operation then proceeds as for typical hysterectomy. The division of the peritoneum is kept well away from the uterus. The uterovesical fold of peritoneum is divided and the connective tissue lying under the peritoneum is dissected up and left attached to the uterine side. In the separation of the uterus from the bladder the dissection is made close to the latter. The ureters should be identified, retracted outward and kept

under observation constantly. The bladder should be separated from the upper part of the vagina.

The uterine vessels should be ligated well out toward the brim of the pelvis. The peritoneal incision on the posterior aspect of the broad ligament should curve out well toward the pelvic brim, and cross the cul-de-sac at its extreme bottom. The uterus now being attached only to the vagina, the upper part of the latter is isolated posteriorly and laterally and cut through well away from the cervix. Experience has shown that the possibilities of recurrence are reduced if the vagina is cut through by means of the cautery knife. The adjacent tissues on the base of the bladder and on the rectum should also be touched with the cautery button.

The broad ligaments should be removed wholly along with the uterus. The ovaries need not be sacrificed.

The connective tissue of the broad ligaments, around the iliac vessels, and as far as the brim of the pelvis should be removed. Any palpable glands within the zone of the uterine lymphatics should be taken away.

The vagina should be closed, with the exception of a small opening for a drain. The peritoneum should be sutured over all (see above).

This radical operation for cancer of the uterus has a high primary mortality. In skilled hands it is from 10 to 15 per cent., and the average mortality is, perhaps, twice that. The ultimate cures in skilled hands range from 20 to 40 per cent. These figures are based on reports of cases of both cervical and body disease. Deaths are due to shock, peritonitis, hemorrhage, embolism of lung, pneumonia, sloughing of the ureters and pyelitis. Cystitis is apt to follow most operations. It is best treated by permanent catheter drainage for a few days.

The danger of peritonitis is minimized in hysterectomy for cancer by the *combined abdominal and vaginal operation.* The abdominal hysterectomy is begun by ligating and dividing the ovarian and uterine vessels, dividing the peritoneum and the broad ligaments, and separating the bladder and rectum from the uterus. The uterus is isolated from all of its connections but the vagina. All bleeding is controlled, and the peritoneal folds are sewed over the uterus. This separates the uterus from the general peritoneal cavity. The abdominal wound is closed, and the operation then completed by the vaginal route. Here it is only necessary to cut around the upper end of the vagina, remove the uterus, and control bleeding of the vaginal wall by sutures. The patient has to be changed from the abdominal to the vaginal position during the operation.

It is always a wise procedure to give the patient the benefit of sterilization treatment of the ulcerated surface for a few days before operation. This is best done by removing necrotic tissue with knife, scissors, curet or cautery, and applying iodin or other antiseptic until, when the patient is ready for hysterectomy, a clean vagina is possible. This is advocated because broken-down cancer is infected with all manner of bacteria, to conduct an operation in the presence of which entails great danger of peritoneal infection.

To prevent necrosis of the ureters the dissection about them should be carefully made, and followed by sewing the peritoneum over them.

Cautery treatment of carcinoma of the uterus was perfected by John Byrne, of Brooklyn, New York, forty years ago. His results have never been surpassed. The carcinoma is scraped away with the curet down to solid tissue. Bleeding should be checked before the cauterization can be done effectively. To stop bleeding a saturated solution of zinc acetate may be applied to the wound or a 2.5 per cent. solution of strong acetic acid.

Gellhorn, of St. Louis, used acetone. If bleeding persists, it is well to pack the cavity, and cauterize later.

The surgeon should have an understanding of the relations of the cavity. Cauterization should be thorough, but the bladder, ureters and intestine should not be burned. A cautery, having a dome or knob end, heated by electricity to a light cherry red, is best. It seems most effective when the tissues are not touched but cooked by holding the cautery close to them. Burning of the vagina should be prevented by using retractors covered with thick pads which can be kept moist with cool water. Special water-cooled and vacuum-walled specula are made for this purpose. For cutting and working in narrow places a narrow cautery tip is used. The temperature of the point must vary for different purposes.

For cauterizing a surface, the lower temperatures are best—50° to 55°C. (122° to 132°F.)—if the cancer tissue has been removed by curet or knife down to normal cells. This low degree of heat is employed in regions where it is desired to destroy cancer cells but not the other tissue cells. For carbonization and deep penetration the cherry-red cautery must be used.

The operation as practised by Byrne began by making a circular incision around the cervix. Into this a platinum loop was sunk, and while it was heated it was tightened and made to amputate the cervix. A sharp curet was then used to scrape out the whole uterine cavity. This was dried out, and a red-hot electrode introduced and the whole cavity cauterized. The cavity was dried and treated with a tampon soaked in acetic acid. Then a dome-shaped cautery, heated to a cherry red, was applied to the whole interior of the uterus. This cautery destroyed the entire uterus except a shell. No packing was used as its removal causes hemorrhage.

J. F. Percy has worked out the cautery operation in its finest details. He has invented special instruments for its application and modernized the technic. His water-cooled speculum is a most valuable instrument for the protection of the adjacent tissues from injury by the heat.

While the cautery treatment of cancer had its beginning in dealing with cancer of the uterus, it is valuable also in other regions. All that is said here is applicable to other parts of the body.

The cautery is capable not only of removing the removable disease but also of destroying the disease beyond this area. Leo Loeb found that cancer is devitalized by a temperature but little above normal whereas it is resistant to low temperatures. Freezing does not destroy it. Mouse cancer loses its power to grow after transplantation if subjected to a temperature of 6°C. (13°F.) above normal. This is the secret of the efficacy of the cautery. The heat which removes and destroys the disease penetrates into the tissues beyond and accomplishes the same effect without destroying the normal cells.

If the surgeon places his patient in the lowered head position of Trendelenburg to permit the viscera to fall out of the pelvis, makes a small opening in the median line above the pubes through which the assistant may pass his hand to control the uterus, places a thermometer in the bladder, urethra, and rectum, and a vacuum speculum or water-cooled speculum in the vagina, and then proceeds to cut out the uterus from below by means of the cautery point, he is perhaps proceeding in the most enlightened way to treat cancer of the uterus. The thermometers register a degree of dangerous heat in the bladder and rectum, and the hand of the assistant on the outside of the uterus tells when the heat is penetrating that organ.

Where the uterus is so hot that the hand can no longer hold it, it may be assumed that the cancer cells have been destroyed.

The human hand, encased in a rubber glove, for a short time will tolerate

a heat of 49° to 54°C. (120° to 130°F.). The tissues of the pelvis may be subjected to this heat for a short time. Normal tissues resist a temperature of 55° to 60°C. (132° to 140°F.). Cancer cells are probably destroyed when the temperature reaches 45°C. (113°F.). When we realize that the cautery point has a temperature of 1000°F., its potentiality is appreciated.

This principle, that cancer is destroyed at a temperature which is not destructive to normal cells, is one of the most important facts in the therapy of that disease. It means that while the scalpel cures only what it removes, the cautery cures among the living cells, in all the area beyond its touch, for a distance as far as its heat can penetrate. This is the danger zone in which the fate of the patient lies. It is here that therapy has been most needed and most difficult to apply. The cautery supplies the radiance which illuminates this dark field. It is the agency which crowns our treatment with an aureole of hope.

Fulguration treatment of carcinoma of the uterus can be applied without anesthetic. It is applicable to the same cases as is the cautery. The results seem to be about the same (see Fulguration, page 699).

Radiation treatment of carcinoma of the uterus has much to offer, and is applicable in a large proportion of cases, especially of the nonoperable type (see *X*-ray and Radium, pages 703 and 709).

Acetone treatment of carcinoma of the uterus, first used by G. Gellhorn, is best used in conjunction with the cautery, fulguration or the curet. After removal of the disease with the curet down to solid tissue and the application of the cautery or fulguration, the cavity is dried and crude acetone is poured into the cavity and left there in contact with all of the diseased region for fifteen to thirty minutes. About 15 or 30 c.c. (½ to 1 ounce) are poured in through a tubular speculum. This requires that the pelvis shall be elevated so that the acetone shall not come into contact with the vulva. The acetone has a hardening and scar-producing quality and penetrates possibly as deeply as the heat of the cautery. The fluid is allowed to run out by tilting the table and the cavity is packed with gauze soaked in acetone. A large dry tampon should be inserted in the vagina. The vagina, vulva and perineum may be protected from accidental contact with the acetone by smearing with petrolatum. The vaginal wall should be cleansed with water if any of the fluid touches it. The application of acetone is made two or three times a week, beginning four or five days after the curettage. As the size of the cavity diminishes, smaller tubular specula are used.

The cavity tends to become smaller and smooth; and hemorrhage and offensive discharge cease.

Prognosis in carcinoma of the uterus is difficult to determine. The cases which can be cured are those in which all of the disease can be removed. This we know to be possible in the early stages before wide extension has taken place. The cases which cannot be cured are those in which the disease has spread to inaccessible structures. It is more a matter of time than of technic. There is always a certain amount of bacterial infection and septic absorption going on in connection with the disease, especially after ulceration has occurred. This produces inflammatory infiltration and enlargement of lymphatics which is often mistaken for carcinoma. Carcinomatous lymph nodules are firmer and adhere more closely to the veins than benign nodules.

It is advised that the operation should be kept 2.5 cm. (1 inch) away from the disease. This is often difficult because it would mean removal of the base of the bladder and resection of ureters, and it is very doubtful whether this is to be advised as a routine measure.

In America, cases come to the surgeon so late that there are but few

surgeons who can report any considerable number of actual cures of the disease. This is largely because the first general practitioner who sees the case does not refer it at once to the surgeon but "treats" it himself either because he is ignorant or because he wants the money he can make out of it. In central Europe, cases are operated upon earlier and a larger percentage are cured. Many surgeons in America, doing a large amount of pelvic work, are unable to report a single case of cancer of the cervix as cured seven years after hysterectomy. Some clinics report as much as 25 per cent. of all cases cured.

The primary mortality immediately as the result of hysterectomy is high for so simple an operation—it averages perhaps 20 per cent. in all hands.

The high rate of recurrence is especially among cases of cancer beginning in the cervix. The patients reported cured are cases of cancer of the body of the uterus. Here naturally enters the question of accuracy of diagnosis. The proliferation of the endometrium which is commonly diagnosed cancer is often a mild grade of neoplasm, if it can be called neoplasm at all.

Inoperable cases, those in which hysterectomy is not to be done, are those in which the surgeon finds that not all of the disease can be removed. In these a palliative operation is better. For this reason abdominal operation has the advantage that it enables the surgeon to note the presence of metastases and desist from further efforts.

Incurable carcinoma of the uterus is by no means inoperable. Much can be done for these cases both to prolong life and to make the patient more comfortable (see Incurable Malignant Growths, Vol. I, page 327). Every such case is a plea for the early radical treatment of the disease, and cries out urging that others be saved from such a fate. Popular education upon the subject is necessary. Every woman should know the significance of cancer and the symptoms which should cause her to seek medical advice, or she should submit to examination every three months after the menopause.

Carcinoma cannot dogmatically be declared incurable, because the cure of apparently incurable cases is not infrequently observed.

The disease can be curetted as far as a bed of solid tissue. To this may be added cauterization, fulguration, radiation, or chemical caustics. This treatment, followed by acetone, is capable of producing scar tissue which decidedly hinders the growth and prevents ulceration and offensive discharge. By these means patients may be kept alive and in comfort in some cases for years. The curettage and cauterization may be repeated at intervals of two to four months. Other treatment may be applied (see Vaginal Hysterectomy, Cautery Treatment, etc., above).

Hysterectomy in pregnancy is performed when Cesarean section is indicated in a case in which the uterus is the seat of a disease demanding hysterectomy. It is indicated in cases of carcinoma, tumor, and infection of the uterus in which the above two conditions are present. The delivery of the child is the same as in abdominal hysterotomy. After delivery of the placenta, the uterus is packed with gauze. The broad ligaments are clamped in two places and cut between. The round ligaments are treated in the same way. An incision is carried from one broad ligament cut to the other, curving in front of the uterus at the vesico-uterine fold. The bladder is pressed downward, the uterine vessels ligated, the uterus amputated above the cervix, and the clamped vessels tied. Clamps are removed, the peritoneum is sewed across the pelvis, and the abdomen closed.

If the operation is done for sepsis, or for cancer, involving the cervix, the latter should be removed, and vaginal drainage provided.

After-treatment of hysterectomy cases is not different from that following abdominal section. A gauze pad should be applied to the vulva. The patient should be kept quiet, the bowels gently moved daily after the second day, and the diet simple. Catheterization may be necessary for retention of urine. Gauze packing should be removed from the vagina on the third or fourth day. Subsequent tampons should be changed every second day. The head of the bed may be raised to promote drainage. About three weeks' confinement in bed is required in the average case.

THE BROAD LIGAMENTS

Hemorrhage into the broad ligament, if of so severe a character as to demand operation, is best reached through the abdomen. The peritoneum should be incised, clots removed, and the bleeding vessel tied. In some cases, in which the tumor is palpable through the vagina, the operation may be done from below.

Cellulitis of the broad ligament should be treated by the constitutional measures employed in cellulitis elsewhere (see Cellulitis, Vol. I, page 264). The patient should be kept at rest in bed. The bowels should move daily. Hot vaginal douches may be of service. Glycerin tampons are used in chronic cellulitis.

Abscess of the broad ligament should be opened and drained. Unless this is done it is possible for such an abscess to rupture into the peritoneal cavity and cause fatal peritonitis. Usually the opening can be made through the vault of the vagina, care should be taken not to wound the cervical or uterine vessels. An incision is made through the vagina, and blunt dissection carried to the abscess. After washing out the cavity, a rubber drainage tube is inserted. If operation must be done through the abdomen the dangers are much increased (see Retroperitoneal Abscess, Vol. II, page 563).

Tumors of the broad ligament are most commonly *fibromyomata* of the uterus, growing laterally and pushing their way between the folds of the peritoneum. It is often in such cases as these that hysterectomy by bisection of the uterus is the most effective means of treatment. Primary *fibromyoma*, lipoma and cystoma should be treated by abdominal section, incision of peritoneum, and removal, as retroperitoneal tumors are treated.

Varicose veins of the broad ligament (pelvic varicocele) when pronounced, causing symptoms, or threatening hemorrhage, should be treated the same as an angioma—all of the contributing vessels tied, and the mass of veins resected.

THE FALLOPIAN TUBES

Acute salpingitis, whether of gonorrheal, mixed, or nongonorrheal infection should be treated by rest in bed. The bowels should be kept open. A light diet is desirable. The application of an ice-bag to the lower abdomen possibly adds to the comfort of the patient. It is highly undesirable to operate on these cases during the acute stage. Acute peritonitis supervening upon such an infection should be treated by conservative measures (see Peritonitis, Vol. II, page 546). The case may be considered in the same light, so far as the peritonitis is concerned, as peritonitis associated with appendicitis. Rest of the bowels, to prevent spreading of the infection, is to be secured.

Operation should be considered if there is evidence of effusion in the retrouterine pouch which is accessible through the vagina.

Attempts at removal of the tubes or the breaking up of adhesions in acute salpingitis is dangerous. After the subsidence of the acute attack, when the virulent organisms have perished or become less virile, operations may be done with safety.

Nonacute salpingitis tends to self-healing without surgical intervention. Gonorrheal infection slowly subsides, tending to leave the tubes occluded and adherent, and often requiring later operation for symptoms due to adhesions and connective-tissue contractures. Infection with streptococci, when recovered from, rarely requires later operative attention. Operation is most commonly required for abscesses, of gonorrheal origin, in connection with the tubes. Pus is found in the distended tubes and confined by adhesions external to the tubes, behind the broad ligaments, in the cul-de-sac, and within the broad ligaments. When such collections of pus are not evacuated, they tend to become absorbed and slowly disappear, or to rupture spontaneously. The surgeon is often surprised to see such masses gradually melt away and even extensive adhesions disappear without operation. The tubes are apt to remain occluded.

A palpable abscess is best operated upon. Operation, in skillful hands, gives the best prognosis. When the abscess is in the cul-de-sac or when a pus-distended tube is in the cul-de-sac and palpable through the vagina, the *vaginal operation* may be done. If the vagina is roomy, a transverse incision is made in the posterior fornix. The finger inserted in this opening dissects its way to the pus. After its evacuation a rubber tube is placed in the opening for drainage. This operation has the advantage of safety, and the disadvantage that the bad position of adherent structures is not corrected.

Most of these cases with extensive adhesions and some pus are best treated by *abdominal section*. The treatment of the tube is most important. In some cases, seropus can be squeezed out and no incision is necessary. In other cases the tube may be incised, pus evacuated, and a small drain carried out through the abdominal wound. In other cases a part of the tube must be amputated. When this is done the incision should be oblique, and the mucous membrane should be sewed to the peritoneum with the view of preserving the patency of the tube (see Operations for Sterility, page 429).

It is well to attach it close to the ovary so that ova may find their way into it. In cases in which there is disease of the whole tube and suppuration, it may seem best to sacrifice one or both tubes. When this is done the ovaries should not be removed. When the whole tube is removed, it is simply ligated close to the uterus cut off and the mucous membrane of the stump external to the ligature sterilized by chemical or heat (salpingectomy).

What has been said above under nonacute salpingitis applies to what are commonly called also *subacute salpingitis* and *chronic salpingitis*. In the latter condition are found the relics of infective processes. Adhesions and infiltration with inflammatory products often cause so much distortion or pressure upon neighboring parts that the mass of damaged tube must be removed. The symptoms must guide the surgeon. A distorted and adherent tube which is producing no symptoms need not be removed. Time will often melt the adhesions and straighten out a crooked tube better than surgery.

Such a tube which gives rise to symptoms should be operated upon. Its removal is often the solution of the problem. Often the surgeon will be rewarded for his interference by finding that it embraces still a collection of pus.

Tuberculous salpingitis should be treated upon the same general principles as are laid down for all forms of tuberculosis (see Tuberculosis, Vol. I, page 276; and Tuberculous Peritonitis, Vol II, page 554). The hygienic treatment is the most important. If the disease is limited to removable organs and their removal can be accomplished with little or no depression to the patient, the operation should be done. Peritonitis of the Fallopian tubes is usually associated with the same disease involving the ovary and uterus, and often the peritoneum. Abdominal section is of benefit to the latter, but there is no use in removing tubes and ovaries if the uterus is involved, or in removing the uterus also if the peritoneum is involved. None of these operations have much to offer if there is tuberculosis of the lungs; and all do more harm than good if much depression is caused by the procedure.

Operations on the tubes for the cure of sterility (to restore the permeability of the tube) are usually required after inflammatory disease or operation. If the end of the tube is buried in adhesions, it should be liberated and so

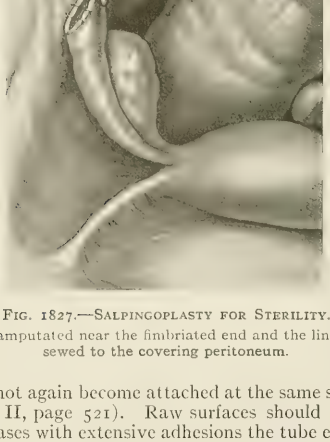


FIG. 1827.—SALPINGOPLASTY FOR STERILITY.
The fallopian tube is amputated near the fimbriated end and the lining mucous membrane sewed to the covering peritoneum.

placed that it cannot again become attached at the same site (see Prevention of Adhesions, Vol. II, page 521). Raw surfaces should be covered in with peritoneum. In cases with extensive adhesions the tube end should be freed, and, if much disorganized, it should be amputated, and the mucous membrane sewed to the peritoneum.

In performing this operation, the tube should be cut off obliquely in order to make the opening larger and prevent cicatricial closure (Fig. 1827). Even when the tube has to be amputated near the uterus the opening may be preserved.

Operation on the tubes for inducing sterility are performed (1) in cases in which a small pelvic canal precludes labor and the risks of artificial delivery are greater than the patient wishes to assume; (2) in cases in which organic disease makes pregnancy extra hazardous; (3) in cases in which the woman wishes to obviate the hereditary transmission of objectionable qualities of (*a*) herself or (*b*) a husband who himself declines sterilization; (4) in cases in

which the state desires for the protection of society to prevent the transmission of undesirable qualities of the mother; and (5) in cases in which it is employed in a healthy woman as a matter of personal expediency.

The operation is often done in connection with Cesarean section. Gonorrhea is the most common pathological factor which causes sterilization by occluding the tubes. The operations which are performed are aimed to do what gonorrhea does—seal up the tubes and prevent the passage of ova.

The *technic* of the operation is simple. The abdomen is opened in the median line and the middle of the tube picked up with forceps. A cut is made through the tube and about 1 cm. (⅜ inch) into the broad ligament below the tube at the inner side of the forceps. Each cut end of the tube is grasped with fine forceps, the peritoneum not being included. The broad ligament is stripped back from it for about 1 cm. (⅜ inch). This much of the naked tube is then tied with catgut and cut off. This is done to each of the cut segments. The tube is thus shortened about 2 cm. (¾ inch). This should be done with as little injury as possible to the peritoneum. With a fine needle and catgut the peritoneum is then sutured with its raw edges

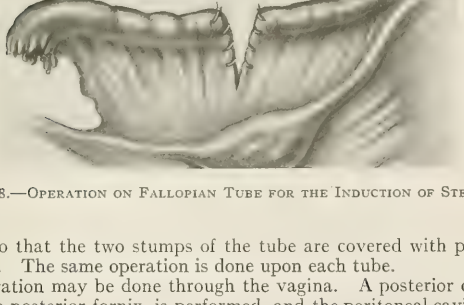


Fig. 1828.—Operation on Fallopian Tube for the Induction of Sterility.

turned in so that the two stumps of the tube are covered with peritoneum (Fig. 1828). The same operation is done upon each tube.

An operation may be done through the vagina. A posterior colpotomy through the posterior fornix, is performed, and the peritoneal cavity opened in the cul-de-sac. A tube is brought down into the opening, its fimbriated end cut off, and the stump inverted by two rows of peritoneal sutures, thus closing the passage of communication between the tube and the peritoneal cavity. Or the middle of the tube may be resected and buried under the peritoneum of the broad ligament as described for the abdominal operation. If the tube is simply ligated in two places and cut across, it is entirely possible for the lumen to become reëstablished.

Blumberg (Berlin klin. Wochenschr., Apr. 21, 1913, No. 16) buried the ovary in a pocket of the broad ligament. The abdomen is opened through the posterior fornix of the vagina. The pocket is made by dropping the ovary into that part of the broad ligament which extends between the Fallopian tube and the ligament of the ovary and suturing the free edges over it. The ovary is thus enveloped in broad ligament; it is movable in this pocket; and when desired the line of union may be separated, and the ovary released.

Operations for restoring the divided tube are done (1) when the tube is

accidentally severed or (2) when operation has been done to induce sterility and sterility is no longer desired.

In recent *wounds of the Fallopian tube*, the tube ends should be sutured together, restoring as accurately as possible the natural relations. With end-to-end approximation, held with three or four fine catgut sutures, permanent patency of the tube may be expected.

In operating *to restore the patency* of artificially closed tubes or wounded tubes, the peritoneum should be incised and the stumps exposed. The closed ends should be cut off and the two lumens brought together and sutured end-to-end. The peritoneum of the broad ligament is used to reinforce the suture line. These operations promise well for restoration of function, if nicely done.

Hemorrhage in the Fallopian tubes rarely occurs independent of tubal pregnancy. Its treatment consists in longitudinal incision of the tube and evacuation of the clot. *Ruptured tube* should be treated by removing clots and ligating the bleeding vessels if hemorrhage is going on. If there is much disorganization of the tube, in some cases it must be removed (see Ectopic Pregnancy, page 435).

Preservation of menstrual function in cases of double *suppurative disease of the tubes* and chronic metritis should always be hoped for. To save a diseased uterus and infected tubes is often difficult, but it is possible to preserve the ovaries and enough of the uterus to carry on menstruation. When infected tubes must be sacrificed and the uterus is found too boggy with chronic infiltration, the tubes may be removed together with a segment of the fundus of the uterus. In performing this operation, the utero-ovarian ligament should be preserved, and the ovarian branch of the uterine artery should be spared. The removed segment of uterus represents the fundus with the extreme upper end of the uterine canal. When the wound is closed, the utero-ovarian ligament, the ovary, the round ligament and the ovarian vessels have been saved in normal connection with the remaining portion of the uterus. Ovulation and menstruation are preserved. The ovary is saved; and the size and weight of the uterus are reduced.

THE OVARIES

Surgery of the ovaries should aim always to preserve ovarian tissue wherever possible so long as it is capable of functionating. The ruthless sacrifice of ovaries, once practised, became inexcusable when the importance of the internal secretion of the ovary was discovered. The ovaries are subject to diseases often requiring operation and removal of tissue, but in many of these conditions there is ovarian tissue which can be left. The wound of the ovary can be closed so that a peritoneal covering remains. By leaving some ovarian tissue the surgeon is often able to save the patient from that most distressing invalidism which is due to the absence of ovarian secretion.

Inflammations of the ovary, when due to acute infection, usually is associated with inflammation of the adjacent organs, which also requires treatment. *Gonorrhea* is the common cause. The treatment of *acute oöphoritis* is the same as that for salpingitis. When abscess of the ovary develops, its treatment should be the same as for abscess of the tubes, excepting that ovarian tissue should be saved wherever possible.

Following acute or chronic irritation or infection there often results *chronic oöphoritis* or *peri-oöphoritis* in which fibrous tissue is deposited and the elasticity of the ovary diminished. For the pain and cystic degeneration, which arise from this condition, resection of a part of the ovary, as practised for cystic degeneration (*q.v.*), often gives relief.

In *tuberculosis of the ovary* the treatment is the same as that for tuberculosis of the tube (see page 428). The disease is so rarely found confined alone to the ovary that its treatment must be considered along with that of other organs.

Cystic degeneration of the ovary, characterized by the formation of small cysts which may be seen bulging at the surface of the ovary, if it gives rise to symptoms, is treated by resection of the most diseased portion of the organ. That part of the ovary containing the largest cyst should be removed by a wedge-shaped resection. Smaller cysts may be punctured with the point of the knife.

The ovary is caught at either end with small clamps which are steadied by an assistant, or the organ is held between the fingers. A wedge, its long axis in the long axis of the ovary, is removed, leaving ovarian tissue on either side (Fig. 1829). The wound in the ovary is closed by a running suture of fine catgut (Fig. 1830). If the suture does not control the bleeding, an extra stitch may be applied.

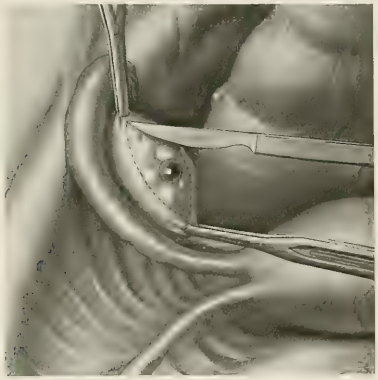


FIG. 1829.—RESECTION OF OVARY FOR CYSTIC DEGENERATION.

Sclerosis of the ovary, when it gives rise to pain because of adhesions and pressure of scar tissue, should be treated by liberating the adhesions. Usually this suffices to give relief; but if there is a dense fibrous envelope, it may be incised the whole length of the ovary, close to the mesoöphoron, and a fold of peritoneum sewed over the cut.

Hematoma of the ovary should be incised, clot evacuated, the wound trimmed smoothly and sutured.

Tumors of the ovary of so great a size or of such a character that all ovarian tissue is obliterated or inseparably involved in new growth are treated by complete removal of the organ. Among such tumors are ovarian cysts, dermoid tumors, fibromyoma, sarcoma and carcinoma. The treatment of all of these is removal. The operation was formerly called "ovariotomy," and was first performed in modern times by Ephriam McDowell, of Kentucky. A cystic tumor as large as 150 kilos (328 pounds) weight has been removed and the patient recovered. The natural tendency of ovarian tumors is to increase in size. Even when not malignant, they kill the patient by pressure

upon other organs. Operation should be done soon after the diagnosis is made.

Operation for Tumor of the Ovary.—The preparations for operation (Vol. II, page 499) should be complete as the surgeon cannot know what conditions may be encountered. Besides the ordinary cutting instruments, hemostats, retractors, and large pedicle forceps should be provided. In operating upon cystomata a trocar and canula are desirable.

A median abdominal incision is made between the pubes and umbilicus. This incision should be large enough to permit delivery of a solid tumor. The hand may be passed in the abdomen to determine the presence of adhesions and the nature of the growth. Adhesions should be separated (see Vol. II, page 520). A solid tumor may be grasped by heavy tenaculum forceps or manipulated without instruments. It should be rotated or tilted to bring its smallest dimensions in contact with the edges of the abdominal opening and the tumor delivered through the wound. The wound may be enlarged if

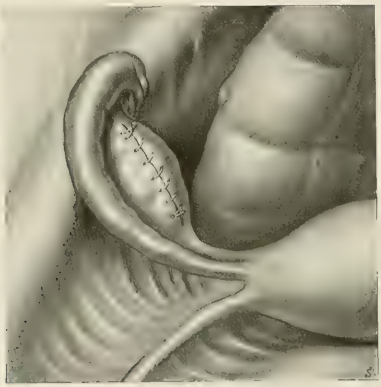


FIG. 1830.—RESECTION OF OVARY FOR CYSTIC DEGENERATION COMPLETED. Wound closed by continuous catgut suture.

necessary. The intestines should be protected, and the skin should be covered with protectors up to the edges of the wound.

In the case of a cystic tumor, it is not necessary that the wound should be large, as the size of the tumor may be reduced by drawing off the fluid. In doing this the intestines should be well protected with absorbent pads, so that the irritating contents of the cyst shall not come into contact with the peritoneum. A trocar-canula, with rubber tubing attached, is plunged into the front of the cyst, and the fluid drawn off (Fig. 1831). In the absence of such a device, a small puncture may be made in the cyst and the pointed end of a rubber tube inserted. The opening should be so small that the tube fits tightly. In the absence of any such apparatus a puncture with a knife may be made slightly to one side of the middle, and by making pressure on the tumor the fluid may be projected into a receptacle at the side of the table. As the cyst is emptied of its contents it is drawn out of the opening, and delivered on the abdomen. By applying forceps at either end of the puncture in

the cyst it may be steadied. In case of multilocular cysts the several loculi may be punctured through the one opening in the external wall. In the case of *dermoid cysts* of the ovary, the fluid is acid and especially irritating to peritoneum. The cyst should be removed unopened if possible.

As the tumor is drawn out of the abdomen, adhesions are watched for and gently separated by the fingers, pushed back, or if very dense, cut. When intestines or other important structures are closely adherent to a benign tumor the dissection should keep close to the latter and if necessary leave some of the tumor adherent to the intestines. Bleeding vessels on the tumor should be clamped. Vessels on other structures should be tied.

As the freed tumor is drawn out of the abdomen it is found to be attached only by a pedicle. This pedicle is the ovarian ligament or ovarian reflection

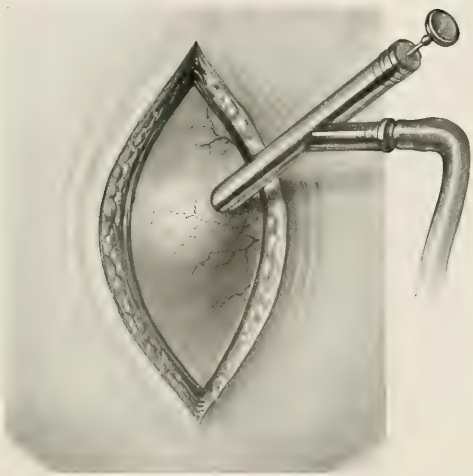


FIG. 1831.—EVACUATING CYST OF OVARY.
Trocar with cannula, connected to rubber tube, thrust into cyst.

of the broad ligament. It contains the ovarian artery and veins, which in the case of a large tumor will be found much hypertrophied. Unless haste is necessary, each vessel of large size should be tied separately by transfixing the pedicle. A pedicle clamp is placed on the tumor side of the ligatures, to prevent blood running back into the wound, and the pedicle cut. The tumor usually has the Fallopian tube attached to it.

The raw edge of the pedicle should be covered by sewing over it the adjacent peritoneum. This is done with a continuous catgut suture, the object of which is to leave no raw surface for later adhesions (Fig. 1832).

The abdomen should be cleansed. If ovarian fluid has escaped into the abdomen, the peritoneum with which it came in contact should be washed with sterile water. After the removal of a large ovarian tumor some warm normal saline solution may be left in the abdomen to make some intraabdominal pressure. The abdomen is closed as usual. The dressing should

make firm pressure to maintain something of the abnormal pressure to which the abdominal contents have become accustomed.

In operating for *papilloma* or *papillocystoma* care should be taken that the papillæ or the fluid containing them do not touch the clean peritoneum or the abdominal wound, as they are liable to become attached and grow, and thus reproduce in the abdominal wall the disease which is prone to become malignant. As much of the growth as possible should be removed. If recurrence takes place the operation should be repeated. Ascites with recurrence of growth calls for drainage.

Parovarian tumors develop in the broad ligament, and the ovary and tube are found attached to the side of the tumor. In the case of *parovarian cystoma* the fluid contents of the cyst are not irritating and, unlike those of ovarian cysts, do no harm to the peritoneum. By incising the peritoneum of the broad ligament the cyst may often be shelled out and the peritoneum closed. When these tumors become adherent to the anterior abdominal wall, it is possible sometimes to remove the cyst without invading the general peritoneal cavity. The ovary often can be saved.

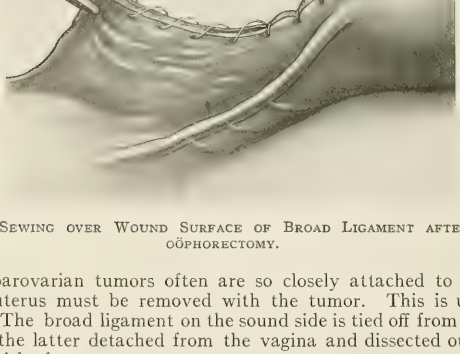


FIG. 1832.—SEWING OVER WOUND SURFACE OF BROAD LIGAMENT AFTER SALPINGO-OÖPHORECTOMY.

Solid parovarian tumors often are so closely attached to the uterus that the uterus must be removed with the tumor. This is usually not difficult. The broad ligament on the sound side is tied off from the uterus, and then the latter detached from the vagina and dissected out laterally together with the tumor.

Malignant tumors of the ovary require no treatment different from that of malignant tumors elsewhere. In dissecting the tumor from adjacent structures the dissection should keep close to the sound tissues. In some cases, in the interest of safety, it is necessary to remove sound tissue even though it mean the resection of bowel. Usually when the disease has gone so far as that, still further deposits are apt to be present.

Torsion of the pedicle of ovarian tumors is treated by removal of the tumor. Unless this is done, the blood supply of the tumor being shut off by the compression of the vessels in the pedicle, absorption of the products of decomposition may give rise to serious consequences.

Prolapse of the ovary is usually associated with adhesions holding the ovary in the cul-de-sac. A prolapsed ovary may require treatment for other

disease but it should not be sacrificed. The ovary should be freed from adhesions, cystic degeneration should be treated, and it should be suspended by shortening the infundibulopelvic ligament. This is done by taking up the slack in the ligament and suturing it to the peritoneum at the pelvic brim. In doing this a suture should catch the peritoneal reflection close to the ovary; and in attaching this at the pelvic brim care should be taken that the needle does not injure the iliac vessels. It is well to catch the sheath of the psoas muscle (Fig. 1833).

Ectopic pregnancy (development of the fecundated ovum outside of the uterine cavity) may be tubal, ovarian or abdominal; but almost invariably it begins in the tube, and becomes a surgical condition by causing rupture of the tube and hemorrhage. The surgical crisis usually occurs between the third and twelfth week after conception, when the tube ruptures and the ovum escapes into the abdominal cavity or into the broad ligament. Diag-

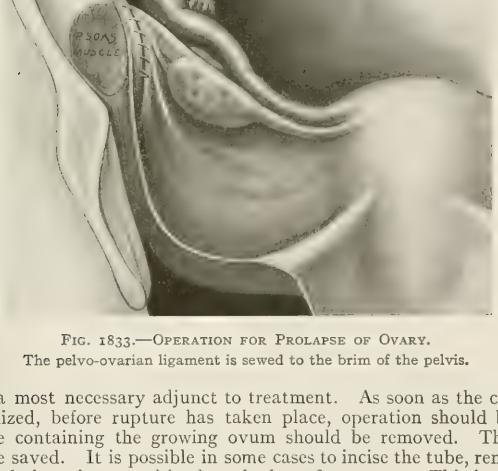


FIG. 1833.—OPERATION FOR PROLAPSE OF OVARY.
The pelvo-ovarian ligament is sewed to the brim of the pelvis.

nosis is a most necessary adjunct to treatment. As soon as the condition is recognized, before rupture has taken place, operation should be done. The tube containing the growing ovum should be removed. The ovary should be saved. It is possible in some cases to incise the tube, remove the ovum, and close the wound in the tube by a fine suture. This is the ideal operation.

The condition should be recognized before a serious condition has developed. Missed menstruation, sudden pain, tender mass behind the uterus, slight fever, and recurrence of pain and enlargement of the mass, should prompt the surgeon to open the abdomen. Sudden severe pelvic pain in a woman who may be pregnant should prompt investigation for ectopic pregnancy.

After *rupture of the tube*, or after *tubal abortion* (escape of the ovum at the end of the tube), hemorrhage and shock call for surgical attention. There is diversity both of opinion and practice among surgeons as to the steps to be taken. Some surgeons advise operation as soon as possible after the

diagnosis of rupture is made. They contend that the danger is from hemorrhage, and that where bleeding is going on the surgeon should interfere at once. Statistics show that the mortality among patients, operated upon during the acute depression incident to hemorrhage and shock, is about 50 per cent., and that among patients operated upon after hemorrhage has ceased the mortality in skillful hands is less than 5 per cent. Of patients treated by rest and the general constitutional measures employed in internal hemorrhage, in about 95 per cent. the bleeding will stop and the patient recover from the immediate dangers of hemorrhage and shock. In most of these the blood will be absorbed and leave but little indication of the accident. In a certain number the convalescence will be prolonged, and in some it will be complicated by abscess or peritonitis.

It is obvious that not to operate at all gives the patient a better chance for life than to operate during the stage of acute depression. Most of these cases are seen by the surgeon after the bleeding has stopped and the patient is recovering from the shock. When it is apparent that the pulse is growing stronger and that hemorrhage is not progressing the surgeon should wait until the condition of the patient has improved to a point at which operation can safely be done.

On the other hand, when the surgeon sees the patient at a time when hemorrhage apparently is going on, he stands in a position in which judgment born of experience is of the utmost importance. If the patient now is operated upon the hazard is very great. Will the bleeding stop spontaneously, and how soon? It is possible for the bleeding in about 5 per cent. of cases to go on and kill the patient. Is this particular case of this class?

As a general plan of procedure for the average surgeon, spontaneous stoppage of the bleeding should be waited for (see Hemorrhage, Vol. I, page 334). This is the general rule for general guidance. As an exception to the above rule, the surgeon of skill and experience in abdominal surgery, who can surround his patient with every measure for preventing shock, should operate at once if the evidences of progressive bleeding are present.

When bleeding has stopped and the patient has recovered from the shock, there is no urgency. Still it is better to do an abdominal operation and remove the clots than to leave their absorption to nature. The abdomen should be opened between the umbilicus and pubes and the blood removed with as little traumatism to the peritoneum as possible. Usually it can best be washed out with warm saline solution. Often the removing of clots causes the bleeding to recur, and one of the early steps necessary is the ligation and removal of the tube. The skillful surgeon may in some cases remove all clots from the region of the wound and suture the torn tube. Usually it is so damaged that it is best removed. Drainage is not necessary unless infection is apparent (see Peritoneal Drainage).

In *cases in which the fetus continues to grow in the abdomen*, it is best to operate and remove the fetus. While it is possible for the child to go on to full term and then be removed alive the dangers to the mother are not inconsiderable and the child usually suffers from developmental defects. Only in cases in which the woman, aware of these facts, still desires the child saved may the gestation be permitted to continue.

In cases in which the child has reached viability or is nearly at that age, operation may be deferred until it is capable of living. The operation is proceeded with as in Cesarean section. The sac is incised and the child delivered. As much of the sac as possible should be dissected away and removed. If possible, the placenta should be removed with it. Time should not be consumed in such dissection if the operation is difficult. Often the placenta

is found attached to important structures. Its removal from such should not be attempted. Rather than prolong the operation unduly, it is best to remove as much of the sac as is free, cut off the cord close to the placenta, and close the wound with drainage.

In *cases in which the fetus is dead*, it is to be removed as a foreign body. Operation is less difficult because there is apt to be less bleeding. The tumor mass may have much the nature of a teratoma, with more or less calcareous deposit in the wall of the sac. This may be removed as far as possible, and provision for a large drain opening made through which the remainder may in time escape.

Transplantation of Ectopic Pregnancy from Fallopian Tube to Cavity of the Uterus.—This operation was successfully carried out by C. J. Wallace (Surg., Gyn. and Obst., May, 1917). A nulliparous woman, who had been married five years and who desired children, had a fibroid in the posterior wall of the uterus. Wallace operated for the fibroid, and upon opening the abdomen found an ectopic pregnancy in the tube. The fibroid was the size of a hen's egg. It was removed. Wallace then proceeded to open the tube carefully and dissect out the young ovum. To avoid breaking the sac a part of the tube wall was left attached to it in places. Its size after removal was about that of a large olive. It was placed at once in the cavity of the opened uterus through the wound by which the fibroid had been removed. It was caught by two sutures of the inner row of No. 1 catgut used in closing the uterine wound. The wound in the tube also was closed.

The patient made an uncomplicated recovery. She left the hospital on the fourteenth day after the operation. The pregnancy went on normally to full term, and resulted in the natural birth of a perfectly developed boy 228 days after the operation.

Hermaphroditism.—This condition is but little amenable to surgical treatment. The condition should be recognized early and the child reared as of the sex, the characteristics of which are dominant. True hermaphroditism may be said not to exist. If there is doubt the child should be regarded as a male. Operations for hypospadias, undescended testicle and for the construction of a vagina are indicated in some of these cases. An abdominal operation to determine just what organs are present is of value and justified in some cases.

Sterility in the Female.—A healthy woman living in normal wedlock, with no social reason for limitation of offspring, should have a child every two years. A woman, married to a healthy man, who has not become pregnant after three years of desire, may be regarded as sterile; although this decision can never be absolute in a woman with ovum-producing ovaries and the other organs of conception. Absence of the ovaries or absent or rudimentary uterus are defects which surgery has not been able to remedy. Improvement of the general health of the woman is important. The use of animal extracts such as of the ovary and the thyroid are often of service.

In the case of *ovaries* which are embedded in inflammatory tissue, from which ova cannot escape, they may be liberated from adhesions by operation, and cystic degeneration treated. Ovaries which are covered by a thickened tunic may have the sclerotic covering removed at its thickest part and cysts punctured (see Surgery of Ovary, page 430).

Occlusion of *Fallopian tubes*, which is usually due to inflammation, is treated by freeing the tube from adhesions, and connecting its lumen as an uninterrupted passage with the peritoneal cavity (see Surgery of the Tubes, page 428).

Occlusion in the *uterus*, due to stenosis of the canal or angulation, should

receive appropriate treatment (see Surgery of the Uterus). Many cases of sterility, not due to gonorrheal infection, are of uterine origin. Anteflexion and a small canal are commonly present. These women may be cured of their sterility by dilating the uterine canal (see Dilatation, page 398) and correcting the flexion (see Anteflexion, page 385, and Dysmenorrhea, page 394).

The mucus plug which so commonly occludes the cervix should be removed and the mucus dissolved with a paste of bicarbonate of soda. If chronic endometritis is present it should be treated. Curettage and packing the uterine cavity with a strip of gauze which has been soaked in tincture of iodin, and leaving it in the uterus for fifteen minutes is effective. The introduction of a wire intra-uterine pessary (Outerbridge) to prevent recurrence of flexion and to hold open the canal is useful. Often these women become pregnant while wearing the wire pessary.

The secretion of the *vagina* must be agreeable to the spermatozoa. The vaginal secretion of some women is spermatolytic to the semen of some men and not to others. This is a chemical problem, with which surgery has little to do.

If the vaginal secretion is acid, it may be made more agreeable to spermatozoa by a douche of sodium bicarbonate and sodium phosphate, 30 Gm. to the liter (1 ounce to the quart) given before retiring.

In cases of defective mobility of the spermatozoa, impregnation has been accomplished by receiving the seminal discharge in a sterile condom and injecting it into the uterus under very gentle pressure with a sterile syringe. The penis should have been rendered surgically clean before the condom is donned. Serious infection has followed this operation when rigid asepsis was not observed.

Deficient Ovarian Secretion.—This condition, occurring in women with disease of the ovaries or following removal of the ovaries, may be benefited by supplying to the organism the missing internal secretion either from another animal or by transplanting ovarian tissue from another woman. This therapy has not yet passed the experimental stage; but the results thus far reported justify its trial.

Ovarian extract itself does not fully satisfy the needs of the organism. Extract of the substance of the *corpus luteum* seems to have a specific action. This is secured from the pregnant cow or sow. It is used in capsules, each containing 0.3 Gm. (5 grains). From three to six of these are given daily. One capsule 3 times daily reduces blood pressure within a week; and for this reason the effect must be watched closely. This drug is capable of re-establishing menstruation in premature menopause, and benefiting women suffering from deficiency of ovarian tissue.

Transplantation of the Ovaries From One Woman to Another.—This operation, so far as I know, was first done in the human female by myself in 1904 (J. P. Warbasse: "Ovarian Transplantation," New York Medical News, lxxxvii, 1905). It is indicated in cases in which the removal of the ovaries has been followed by the distressing symptoms due to the absence of ovarian secretion. The operation is a substitute for the administration of ovarian extracts.

In heteroplastic transplantation I have proceeded as follows: The two women are operated upon simultaneously side by side. The abdomens are opened. The donor should be willing to part with a good ovary or one which is but slightly cystic. The ovary should be removed and handed over for immediate implantation in the other woman. A bed for this should have been prepared by making a slit in the peritoneum of the broad ligament just

internal to the pelvic brim at the side of the bladder. The ovary is inserted in this slit, its raw surface in contact with the connective tissue, its peritoneal surface appearing through the opening, and held by four fine sutures of catgut (Fig. 1834).

Autoplastic transplantation should be done in the same manner in cases in which the ovaries must be removed from their natural attachments. This is often called for in operations for the removal of the uterus with myomatous tumors.

Genital Tuberculosis in Women.—Prevention and treatment are the same as for tuberculosis in other parts as it is rarely primary, and as death is rarely directly due to genital tuberculosis but usually to the disease in the lungs or intestines, its importance is secondary to that of the disease in other organs. Operation is of value only in cases in which an isolated focus of tuberculosis is discovered and can be removed. The emphasis should be laid upon constitutional treatment, aiming to increase the resistance

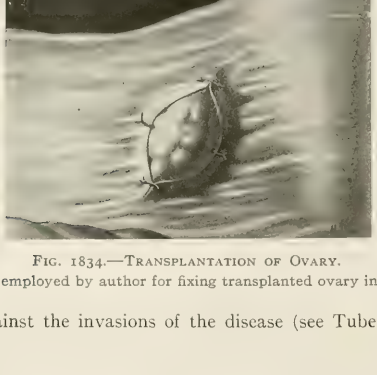


FIG. 1834.—TRANSPLANTATION OF OVARY.
Showing method employed by author for fixing transplanted ovary in broad ligament.

of the body against the invasions of the disease (see Tuberculosis, Vol. I, page 276).

VAGINAL OPERATIONS WITHOUT THE USE OF AN ANESTHETIC

Certain parts of the genital tract are so poorly supplied with sensory nerve endings that operations may be done within these areas without the use of either general or local anesthesia. These areas are not constant, but the absence of sensation can be determined easily by making the test.

These areas are the mucous membrane of the vagina on the anterior and posterior walls. Sensation is present over the zone about 6 mm. ($\frac{1}{4}$ inch) from the cervix and the same distance from the skin of the vulva. Between these two narrow zones at the two extremities of the vagina is a strip of the anterior and posterior walls about 13 mm. ($\frac{1}{2}$ inch) wide in which operations may be done without anesthetic. The lateral walls of the vagina are sensitive.

The cervical portion of the uterus, both as to its vaginal surface and its canal, is but poorly supplied with sensation. The whole cervix is somewhat

sensitive to dilating or pressure forces. The mucous membrane lining the fundus of the uterus is without sensation. There is some slight sensation along the uterine canal between the cervix and the fundus, but in most cases this is quite negligible.

This means that operations may be undertaken in these areas without the aid of anesthetic agents. Operations for endometritis of the fundus and cervix by curettage and the application of caustic antiseptics to the whole canal are possible. Access to the uterine cavity may be secured not by dilating the cervix but by incising the cervix. Cutting operations for repair of the lacerated cervix or for amputation of the cervix may be done. Operations for uterine flexions and prolapsus are possible. In the vagina operations for vesical or rectal fistula may be carried out without anesthetic as far as the mucous membranes of the bladder and rectum which are but slightly sensitive. Operations for cystocele and rectocele may also be carried out in the same way.

Fractures, inflammations and tumors of the clavicle, scapula, humerus, radius and ulna, carpal bones, metacarpal bones and phalanges are discussed in the chapters on Diseases of Bones, Operations on Bones, and Tumors.

Dislocations of the acromioclavicular, shoulder, elbow, radio-ulnar, wrist, carpal, carpometacarpal and phalangeal joints are discussed in the chapter on Dislocations.

Injuries and diseases of blood-vessels are discussed in the chapter on Blood-vessels.

Injuries and diseases of nerves are discussed in the chapter on Nerves.

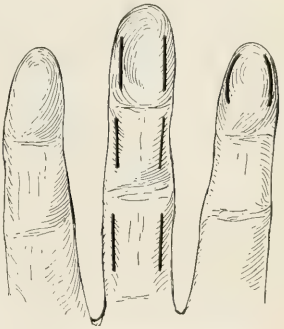


Fig. 1835.—Incisions for Infections of the Finger.

Felon.—In osteitis of a phalanx, a diagnosis should first be made. The condition should not be confused with cellulitis or lymphangitis without involvement of periosteum or bone. Incision down to the bone should be made at once. Nitrous oxid anesthesia is to be recommended. Time should not be wasted with tentative treatment. If there is a localized tender area the incision should be made through it. If there is no localization, but only

Fig. 1836.—Incision for Felon and Placing Rubber Tissue Drain. Method of Dorrance.

general swelling and pain, the incision should be made at one or the other sides of the phalanx, midway between the dorsal and the palmar aspects.

This incision should be in the long axis of the finger. If it is made in the palmar surface it leaves a scar in the most important tactile part. Lateral incision reaches the infection just as well (Fig. 1835). The lymphatic spaces from the skin lead directly into the bone, and when they are opened good drainage is secured. G. M. Dorrance connected two lateral incisions by continuing the cut across the tip of the finger in cases of felon of the distal phalanx. This operation virtually turns down a large palmar flap. It permits the placing of a drain across the whole finger, and is the most effective operation (Fig. 1836). After a thin drain of rubber tissue is placed at the apex of the wound the flap is pressed back in place (Fig. 1837).

Early incision stops the disease. If incision is not made in time, necrosis of the phalanx takes place. This necrosis may extend to the soft tissue; and it is not uncommon to see a slough of soft parts as well as of bone. The whole terminal phalanx may exfoliate. Often the end of the bone will be found completely surrounded by pus. In such a case the diaphysis should be cut off leaving the epiphysis attached to the joint. In children the diaphysis may separate from the epiphysis so that it can be cut free with scissors. The removal of the diaphysis of the bone leaves the joint unimpaired; the finger is slightly shortened and blunted at the end.

The best dressing after incision is a copious gauze swathing, wet with hot antiseptic solution. Boric acid is especially useful. Elevation of the hand prevents throbbing pain. After the acute process has subsided, ointment should be added to the dressing to prevent the gauze adhering to the wound.

Treatment of felon by constriction hyperemia, followed by small incision, and suction hyperemia, in Bier's hands has given good results.

To abort a felon, some surgeons report success with the following treatment: The affected part is enveloped in a mass of absorbent cotton saturated with alcohol. Over this a thin rubber finger-stall is applied to exclude the air. The essentials are alcohol in contact with the skin and air exclusion to prevent evaporation. One to three days of this treatment are said to give relief. Surgeons continue to report successes from this treatment; I have repeatedly tried it with but little satisfaction.

FIG. 1837.—DRAIN PLACED AND FINGER READY FOR DRESSING.

Paronychia.—This infection of the soft tissues which usually begins at the side of the nail in a wound caused by a strip of loose skin, should be treated by liberation of the confined pus, which commonly burrows under the proximal end of the nail.

In cases which have not yet developed abscess, a copious wet dressing of hot boracic acid solution is most effective.

For the liberation of the subungual pus the surgeon has the choice of two methods.

Seff and Berkowitz (Jour. Am. Med. Assoc., July 17, 1915) devised the following treatment for both acute and chronic cases: The finger is placed flat on the table. The skin is pressed back from the root of the nail by means of the flat side of a probe until the upper edge of the nail is uncovered.

This operation may be facilitated by soaking the finger in hot boracic acid solution. With care this may be done with little or no pain. The flat end of the probe is then inserted under the nail, and the nail split longitudinally in its middle with sharp scissors for a distance of 4 mm. ($\frac{1}{8}$ inch).

Each side of the cut is then grasped with forceps and the nail cut transversely on either side. This operation should remove the upper part of the nail which has already become separated from its bed. The distal part of the nail should be left, as any attempt to remove it is very painful and unnecessary. A wet dressing of warm boracic solution is applied and the patient is instructed to soak the finger in hot boracic solution if it should become painful.

The old and commonly employed treatment is by longitudinal incision to liberate the pus, after which a wet dressing, changed daily, completes the cure. If incision to liberate pus is resorted to, it is best made at the side of the finger. The nail-bed should not be incised. If pus has found its way under the nail, the soft tissue at the side of the nail should be retracted, and, with sharp scissors, the part of the nail, which has been separated by the pus from its bed, should be cut away. The wound should be packed with ointment and a wet gauze dressing applied.

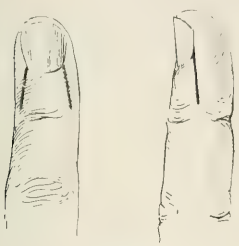


FIG. 1838.—INCISIONS FOR PARONYCHIA.

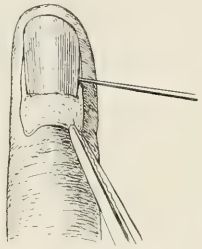


FIG. 1839.—OPERATION FOR PARONYCHIA.

The flap of eponychium is turned back, and the root of the nail is lifted up for drainage.

If the abscess under the nail extends across to the other side, an incision is made on each side of the nail (Fig. 1838). The nail-bed should not be cut. The skin (eponychium) at its attachment to the nail should be pressed back and the root of the nail exposed (Fig. 1839). With sharp scissors the root of the nail which has been detached by the suppuration should be cut away, leaving the distal part of the nail undisturbed. The flap should be replaced and held by a dressing smeared with ointment to facilitate its removal. A new nail rapidly forms and moves forward with the remains of the old nail.

This operation by incision of the soft parts is indicated only in cases in which the skin cannot be pressed back far enough to uncover the whole nail without incision, and in cases in which an abscess within the soft tissues exists.

Cellulitis of the Finger-tip.—This condition, sometimes called superficial felon, should be treated by a big dressing wet with hot boric acid solution. The induction of hyperemia by elastic constriction is of service. The disease should not be mistaken for true felon. Felon requires incision as soon as diagnosed; cellulitis does not. Cellulitis should be incised only when an abscess has formed. But when abscess has formed, incision should

be made. The incision should be made over the abscess, preferably at one or the other side of the middle of the finger.

Cellulitis which has gone on and produced infection of the bone (secondary felon) should be treated as felon. Incision down to the bone should be made at once.

Subcutaneous Abscess.—Abscess near the nail or on the palmar aspect of the finger-end, covered only by skin, should be treated by removing all of the elevated skin, and dressing the surface with powder or ointment.

Syphilis of the Finger-tip.—*Primary chancre* of the finger, not uncommon in the surgeon, should be treated the same as the primary lesion of syphilis in other parts (see Syphilis, Vol. I, page 283).

Tuberculosis of the Finger-tip.—When this condition is an isolated infection it should be treated by destruction of the whole sphere of infection. The best way for the surgeon to do this is to apply rubber constriction to prevent bleeding, sterilize the skin, anesthetize the area to be operated upon, cut out the disease, and close the wound. If the disease is more extensive an open wound must be left, or it may be covered by a plastic operation. If the disease has extended to involve the bone, amputation or resection is the operation of choice.

Carbuncle of the Hand.—This condition requires much the same treatment as in other parts. The best treatment is crucial incision, the ends of each incision passing beyond the area of infiltration. If the incisions do not pass into sound tissue beyond the infected area, extension of the disease is apt to take place. A short general anesthesia is usually necessary. If there is a central necrotic mass, it should be removed. The four flaps should be lifted up and a packing of gauze introduced into the recesses of the cavity. Even though the skin looks badly it need not be removed; it has great power of regeneration. At the end of a day the packing may be removed, the flap allowed to fall back, and wet dressings employed.

DEEP INFECTIONS OF THE FINGERS, HAND AND ARM

Infections of the fingers, hand and arm are so common among working people and so inadequately treated that much emphasis should be laid upon their importance. The sacrifice to these infections, of useful limbs and lives is one of the reproaches of our social system, which fails to provide adequate surgical training, and fails so constantly to bring together the man with the infected hand and the surgeon who knows how to treat it.

The general nourishment, hygiene, and comfort of the patient should be looked to, as it is his reserve resistance that must be depended upon to prevent the condition becoming critical and to save him in the event of the infection taking a serious turn.

In deep infections, incision is demanded in cases in which (1) abscess has formed, (2) infection of bone is present, or (3) suppuration within the tendon sheath has occurred. Cases in which an uncomplicated cellulitis exists are best treated by the measures already described (see Cellulitis, Vol. I, page 264).

These measures, as applied to the hand and arm, require special consideration. **Rest** is important as it tends to prevent pain and spread of the infection. It is secured by keeping the parts quiet by the splint-action of a dressing and by having the patient abstain from work. Rest should amount to immobilization. It is more important in these cases than it is in fractures. Splints should be added to the dressing if necessary to secure it. For pain, elevation of the hand on a pillow above the rest of the body reduces the

amount of blood in the part and gives relief. Elevation should be used only as a temporary expedient.

The induction of **passive hyperemia** is of service in most cases. I agree with Kanavel[1] that its chief value is in three conditions. The first of these is in acute lymphangitis or after incising a virulently septic area, in which it is desirable to prevent the rapid absorption of septic material. In these cases, tight constriction reverses the lymphatic current and tends to carry such substance out at the wound. It is also of service in semichronic infections in which some swelling, redness, and fever persist. In localized suppuration which does not heal promptly, the suction cup is useful. In other conditions, artificial hyperemia induced by mechanical apparatus, may be of value as an adjunct to treatment, but it can not be regarded as the most important measure.

As a general treatment, applicable to all conditions, the use of **hot wet dressings** is the oldest and most useful measure at our command. In addition to heat and moisture, antiseptic action may also be secured. For this purpose a saturated solution of boric acid is to be recommended. Solutions of mercuric salts may irritate the skin; phenol may cause gangrene; iodin and chlorin solutions are irritating to the skin and do not penetrate. It is well to keep on hand a saturated solution of boric acid, sterilized by boiling. This may be heated whenever needed. Sterile gauze should be applied to the part and then the hot solution poured on the gauze. The dressing should be voluminous. As much of the hot solution should be poured on the dressing as it will hold without making a muss. The temperature of the solution should be as high as can be borne by the surgeon—not by the patient, as the sensitiveness of the skin of the latter may be much reduced by the disease.

The gauze, soaked with the hot solution, should extend well above and below the diseased area. To hinder evaporation, it should be covered by a layer of oiled protective, rubber tissue, paraffined paper, or other impervious material. Over all should be placed a layer of cotton, and the whole held by a gauze bandage. The dressing should not be allowed to become dry. It should be moistened every two or three hours with the hot solution, which may be poured in at either end between the dressing and the skin. Or a trap-door may be left just over the disease, and the solution poured in here.

The whole dressing should be removed daily and the parts inspected. Two critical periods should be looked for. One is the subsidence of the infection to such a degree that the treatment should be changed; the other is the appearance of conditions requiring incision.

As soon as the infection has abated, the treatment should be discontinued, as maceration of the parts in the moist pack then tends to produce bogginess and stiffness. Massage and motion are now indicated to hasten absorption of round cells and serum. If there is still some infection dressing with alcohol is of value.

If there is doubt as to the need of incision, the surgeon should be on the safe side, and not incise. Instead of plunging in a knife and possibly opening an uninfected tendon sheath, it is best to proceed with caution.

When incision is indicated, the skin should be rendered sterile. General anesthesia should be used. The limb should be elevated and the Esmarch rubber bandage applied from the upper limit of the infection to the axilla.

[1] The reader is advised to consult the admirable work of A. B. Kanavel on "Infections of the Hand," Lea and Febiger, 1912.

The surgeon should then carefully cut down and see just the condition of the tissues. If there is question as to the infection of a tendon sheath, the sheath should be exposed and inspected before it is opened. If it bulges and has the appearance of being distended, it may then be incised. If there is doubt, a fine aspirating needle may be inserted and some of the contents drawn off. If this is found to be turbid, infection of the synovial sac may be judged to be present and free drainage should be provided (see Drainage of Tendon Sheaths, Vol. I, page 817; and Suppurative Tendosynovitis, below).

Suppuration may be connected with the bone. This may be incised without opening the tendon sheath.

The rubber constriction should not always be removed at the end of the operation as an overwhelming dose of toxins may be thrown into the circulation. It is best to loosen the constriction gradually during a period of twelve to twenty-four hours, thus securing also the benefit of passive hyperemia.

Many surgeons have taught that incision should be made in all these cases, upon the assumption that if no pus is present the drainage will do good. This is a mistake. Such incisions, which do not drain pus, do more harm than good.

After adequate incisions have been made, drainage usually is assured without anything further being done. As a precaution for keeping the wounds open, nothing is better than strips of gauze impregnated with sterile paraffin or some bland ointment, such as sterile zinc oxid, which prevents granulations growing into the gauze. Strips of rubber tissue are also good. Rubber tubes are not to be recommended, as they are apt to cause pressure necrosis. The wounds should not be pressed and squeezed as there is danger of forcing pus into uninfected spaces. The gauze strips need rarely be left in longer than a day. By that time the pus has found a channel and will continue to escape. Necrotic tissue should be picked out with forceps or cut away.

The dressings should continue to be made with hot boracic acid solution until the acute infection has abated. Then dressings with alcohol may be used. Passive motion and massage should complete the treatment.

The old method of making multiple incisions here and there and drawing rubber tubes through the hand or arm is no longer employed. As to continuing the use of tubes or gauze drains longer than two days, it is rarely called for.

Acute suppurative tendosynovitis, in acute infections of the hand, deserves especial consideration. In the early stages of an infection, before a diagnosis of tendosynovitis can be made, the treatment should be that described above. When the symptoms of tendosynovitis are evident the tendon sheath should be opened and drained. This operation should be, as described above, in a non-bleeding field. Under general anesthesia and the use of the rubber bandage, dissection down to the sheath of the tendon should be made.

The surgeon should have an understanding of the anatomy of the bursæ and tendon sheaths. They are by no means constant. The sheaths on the flexor surface are most important (Fig. 1840). It should be noted that the sheaths of the flexor tendons of the *index, middle,* and *ring fingers* extend from about the level of the last phalangeal joint about to the middle of the palm of the hand. The sheath of the flexor tendon of the *little finger* and the *ulnar bursa* communicate in, perhaps, one-half of the cases. The superficial palmar arch lies superficial to the sheath. The ulnar bursa passes a

finger's breadth above its upper border up under the annular ligament. The sheath of the long flexor tendon of the *thumb* and the *radial bursa* almost always communicate. The tendon sheath begins at the distal phalanx and the bursa extends up under the anterior annular ligament a finger's breadth above its upper border. There is an *intermediary palmar sheath*, commonly lying between the ulnar and radial bursæ. In some

FIG. 1840.—PALMAR SYNOVIAL SHEATHS.

Common adult type. Either the radial or ulnar sheath may communicate with the central palmar sheath or all three may communicate.

cases the ulnar and radial bursæ both communicate with this sheath and in such cases, infection passes freely between the thumb and little finger.

The six tendon sheaths of the dorsum begin just above the annular ligament and extend down upon the back of the hand. They vary from to 7 cm. (1½ to 2¾ inches) in length, and extend not much below the middle of the metacarpal bones.

In the *index, middle-*, and *ring fingers*, infection of the flexor sheath should be treated by incision of the sheath in the region of the most pronounced

local symptoms. The character of incision must vary with the extent of infection. If the first incision is made at one end of the sheath and pus is obtained, another incision should be made at the other end of the sheath. In the hand, the incisions may be made over the tendon, but in the fingers incisions should be made at one side. The incisions in the finger should be on the side where the greater swelling is. If there is swelling on both sides, incision should be made on each side. An incision should be made at each phalanx excepting the distal phalanx. If there is much swelling so that the swollen tissues tend to close the openings one incision should extend from the middle of one phalanx to the middle of the next, crossing the joint (Fig. 1841).

Through these openings the sheath can be washed out with salt solution. Sloughing tendon should be removed. If there is much swelling the incisions should be long. Adequacy of opening is essential. It is best to make an opening larger than necessary than to make one that is too small. It is often advisable to incise the full length of the bursa, and then put the finger on a split to prevent prolapse of the tendon. It will be noted that no incision is made over the distal phalanx.

FIG. 1841.—INCISIONS OF PALMAR SYNOVIAL SHEATHS.

In infections of the flexor sheath of the *little finger* and *ulnar bursa*, the incisions should follow the same principles as for the other fingers, excepting in that one-half of the cases in which the two sacs are connected. It is usually advisable to make one incision opposite the two upper phalanges on the side of the finger which is most swollen. For the ulnar bursa, if the opening from the tendon sheath to the bursa is small, it is possible for it to become sealed by a slow inflammation. If there is no opening the uninfected bursa should not be opened. These are delicate questions for diagnosis. To open the infected bursa an incision should pass from a point just above the base of the little finger, following the inner side of the sheath to the lower border of the annular ligament. This is best done by inserting a grooved director and following it as a guide (for drainage of the upper end of the ulnar bursa, see Drainage of the Arm, below).

In infections of the sheath of the long flexor of the *thumb* and *radial bursa*, incision should be made into the sheath along the proximal phalanx of the thumb. For infection of the bursa, this incision should be carried upward, keeping toward the ulnar side to avoid the thenar muscles, and end about 2.5 cm. (1 inch) below the annular ligament. If the incision is carried higher the nerve to the thenar muscles is apt to be cut. If drainage of the upper end of the radial bursa is necessary, it is best secured by the method described below for draining infections of the arm.

In infections of the *dorsal tendon sheaths*, the best results are secured by laying open the sheaths for their full length below the annular ligament.

Extension of infections to adjacent parts is most common in neglected cases.

It is best prevented by early incision of infected sheaths. Involvement of the lumbrical spaces calls for connecting these spaces with the incision of the sheath. If there is much pus incisions should be made on each side of the infected finger. If the edema is great, the incisions should be long enough to open the whole infected bursa and allow opening also of the infected connective-tissue spaces.

Incisions of the flexor bursæ are employed for drainage of deep palmar abscesses. A pair of artery forceps, passed through the incision and thence into the deeper abscess and opened, may serve to open up infected spaces without extra incisions being made. If the infection of the lumbrical space is expressed in dorsal swelling, it is often advisable to make a dorsal incision between the metacarpal bones and thus secure through-and-through drainage. Care should be taken not to force the point of the forceps into uninfected areas and thus spread infection.

Infection of the middle palmar space demands early incision which should be placed so as not to open the ulnar bursa if it has not yet become infected. Incision is best made along one of the intermetacarpal spaces. The place of election is between the metacarp of the middle and ring finger. The incision should extend from the base of the fingers 4 cm. (1½ inches) upward in the palm. If the most swelling is in another lumbrical space, the incision should be made where the swelling is greatest. The incision is carried through skin and fascia into the intermetacarpal space. A blunt instrument is then passed through the incision up into the middle palmar space to the infected zone. A strip of gutta-percha tissue or ointment gauze is passed up to the abscess to keep the drainage tract open. It is removed after twenty-four hours. This method of drainage avoids tendons, nerves and vessels.

In cases with *infection of the thenar space and the palmar space*, the intermetacarpal incision is made, and forceps passed behind the tendons and pushed into the thenar space.

Infection of the thenar space is reached by a dorsal incision on the radial side of the metacarpal bone of the index-finger at the middle of the bone on a level with its palmar surface. A blunt instrument is passed across the front of the second metacarpal bone into the thenar space.

Extension of infection above the annular ligament should be treated first by incisions of the bursæ in the hand. The infection of the upper ends of the bursæ being discovered, they should be opened in the forearm. In *infection of the ulnar bursæ*, an incision is made down to the front of the ulna at its outer aspect. The lower end of the incision should be about 4 cm. (1½ inches) above the tip of the styloid process of the ulna. A pair of artery forceps or blunt scissors are inserted in the incision and carried across close to the front of the bone, opening up the infected bursa. When there is also *infection of the radial bursa*, as is commonly the case, the point of the instrument should keep close to the front of the bones, pass across both ulna and radius, and protrude under the skin on the radial side where it should be cut down upon. The incisions should not be shorter than 2.5 cm. (1 inch). By keeping close to the bones the vessels are not injured, and by making the incision on the radial side high enough the radial nerve is avoided.

A retractor should lift forward the flexor tendons. The sheath may then be discovered. If the bulging sheath has not been opened it should be incised. If the sheath is not easily discovered, it may be made to bulge by distending it with water injected through the opening below in the palm. Or a probe may be passed up from below to identify the upper part of the bursa.

By the proper placing of these incisions no drainage material need be

introduced. Rubber tubes cause pressure necrosis. If anything is needed to keep open the wound a strip of rubber tissue is to be recommended.

In exceptional cases a median incision at the wrist, splitting open the anterior annular ligament, may be required (for further description of treatment, see Tendosynovitis, Vol. I, page 817).

The Treatment of the Results of Infections of the Hand.—*Osteitis and necrosis of bone* very commonly occur and require the treatment already described for these conditions (see Osteitis, Vol. I, page 692; and Operations on Bones and Joints, Vol. I, page 688).

Arthritis of the finger, *metacarpal* and *wrist* joints, when suppurating, require incision and drainage (see Operations on Joints, Vol. I, page 737). In treating the finger, it is always advisable to put it up with the joints in semi-flexion, this being the best position in case ankylosis occurs.

Necrosis of tendons, which is very common in acute infections, may be avoided by early drainage of the infected sheath. When necrosis has occurred the necrotic portion of the tendon should be cut away.

Edema after infection is cured, is best treated by massage and use of the hand.

Atrophy and *contractures*, due to the contraction of connective tissue around the blood-vessels and nerves, giving rise to trophic disturbances, is a most distressing condition to treat. Massage, passive motion, and use of the hand help nature to relieve the destructive pressure.

Daily flexion and extension, with passive and forcible motion and massage, while the hand is immersed in hot water are of service. These methods should be employed as soon as the acute infection has gone.

The use of the vacuum suction apparatus of Bier has much to recommend it. The apparatus consists of a vacuum chamber embracing the hand and forearm, with attachments for making passive and forcible movements of the joints (see Hyperemia Treatment of Chronic Inflammations, Vol. I, page 229).

Old contracture of the palmar fascia which is too dense to be cured by the above measures, can be removed by careful dissection and closure of the wound. If much fascia is taken away it should be replaced by transplantation (see page 645).

For the treatment of Joint Malpositions due to contractures of soft parts, see Vol. I, page 682.

Conclusions.—In all of these infections of the hand, the character of the infection must influence the treatment. The fulminating types, caused by the more virulent organisms, demand urgent and immediate radical treatment. The slower infections, caused by the less virulent organisms, may enjoy tentative measures. In all cases the aim should be to give help to the local tissues in resisting the infection and to avoid introducing still more harmful infections. The use of the *bacterial vaccines* and other antibodies has proved of value.

THE SHOULDER-JOINT

For Dislocations, Arthritis, Tuberculosis, Ankylosis and Operations see chapters on those subjects.

Tuberculosis of the Shoulder-joint.—The treatment is the same as that for tuberculosis in other parts (see Tuberculosis, Vol. I, page 276). The humerus should be immobilized by fixing it to the thorax by means of bandages (see Bandages of the Shoulder). The bandage should fix the upper arm at the side of the chest and the forearm across the front of the chest. Several layers of gauze cloth, to absorb the skin secretions, should be interposed between the arm and the body. The position should be entirely

comfortable for the patient. It will often be found that the most comfortable position is in slight abduction. This may be secured by placing a triangular wedge of cloth or a wedge-shaped splint between the upper arm and the thorax. *Comfortable immobilization* is the essential of treatment.

If there are no other tubercular foci in the body, and the focus at the shoulder is localized, the latter may be removed by operation (see Tuberculous Arthritis, Vol. I, page 663 and Shoulder-joint, Vol. I, page 679).

Peri-articular Bursitis of the Shoulder.—When injury or other cause produces an inflammation of the *subdeltoid bursa*, lying between the deltoid muscle and the coracoacromial ligament, a painful condition ensues which has often been mistaken for disease of the joint but which requires only the treatment described for bursitis (see Bursitis, Vol. I, page 819). During the painful acute stage the joint should be kept at rest by bandaging the arm to the thorax in a position of abduction so as to relax the deltoid. This is done by introducing a triangular frame or pad between the upper arm and the side of the chest. In some cases more comfort is secured by resting the arm on a pillow in a position of complete abduction. Hot or cold applications to the shoulder may give additional relief.

If early rest is enjoined, healing without complications may be expected. After the acute symptoms have subsided, passive motion and massage may be employed to advantage. This treatment helps the absorption of exudate and adhesions in and about the bursa. Cases not treated by rest during the acute stage are prone to run on into a chronic bursitis, which is best treated by operation.

The *operative treatment* is called for in cases in which the bursa has become thickened and the seat of chronic congestion and irritation. An incision, 5 cm. (2 inches) long, parallel to the fibers of the deltoid, is made over the bursa. The fibers of the muscle are separated and retracted and the bursa dissected out.

The other bursæ about the shoulder which may be affected are the *subacromial bursa*, the *coracoid bursa* and the *subscapular bursa*. The only treatment which can be depended upon to give a permanent cure in any of these cases is removal of the bursa.

In *tuberculosis* of any of the bursæ, the sac should be removed. *Abscess* of a bursa requires incision and drainage.

THE ELBOW-JOINT

For Dislocations, Arthritis, Tuberculosis, Ankylosis and Operations see chapters on those subjects.

Arthrotomy of the elbow-joint for drainage is best done at the outer side of the oleocranon process or at both the outer and inner sides. One of the incisions employed in resection of the joint may be used (Vol. I, page 742).

Union of the radius and **ulna** at the elbow, congenital or acquired, is treated by cutting apart the bones and interposing muscle, fascia, or other available tissue to prevent bony union (Vol. I, pages 742 and 762).

Cubitus valgus and **cubitus varus of the elbow,** congenital or acquired, may be treated by osteotomy of the humerus just above the condyles, applying the same principles as are applied in correcting the similar deformities at the knee by means of osteotomy of the femur.

THE WRIST-JOINT

For Dislocations, Arthritis, Tuberculosis, Ankylosis and Operations; see chapters on those subjects.

Club-hand, in those cases in which there is no deformity of the bones, is treated by manipulation, and holding the hand in an overcorrected position by plaster-of-Paris or other splint material, after the methods used in the foot. The fixation correction should be followed by massage and electricity. In the cases with deformity of bones, osteoplastic operation, removing bone from the convex side and implanting bone in the concave side, should be done.

Wrist-drop should be treated by restoring, if possible, the function of the musculospiral nerve. If this cannot be done, the inconvenience of the loose joint may be remedied by arthrodesis. This is done by removing the synovial membrane from the articular surface of the radius, from the upper ends of the third and fourth metacarpal bones, and from between the intervening bones of the carpus. The carpal bones to be immobilized are the scaphoid, os magnum, semilunar, and unciform. The gouge and curet are needed for the operation. The hand should be put up on a splint in a position of dorsal extension slightly greater than that of the position desired. Some surgeons have wired the bones. This is not necessary if an effective destruction of synovial surfaces is accomplished (for incisions and technic, see Arthrodesis, Vol. I, page 738; and Resections of Carpus, Vol. I, page 746).

The result of the operation is that the rotation of the forearm is not lost. Supination is limited. The thumb can be approximated to the tips of the index- and little fingers. The grasping and carrying function of the hand is good.

WOUNDS OF THE FOREARM

Wounds of the forearm are peculiar because they often require treatment of several wounded structures. Incised wounds of the front of the forearm in its lower part often involve superficial and deep tendons, the important nerve trunks, and the two larger arteries, as well as less important structures. These cases call for the best surgical skill. The utmost cleanliness should be secured. Bleeding vessels should be ligated. Under constriction anemia, the divided structures should be identified one by one. Nerves and tendons should be sutured. Before beginning the suture of tendons, the surgeon should make sure that divided tendons are reunited and not sutured to another tendon as has often been done. Each tendon should be carefully sutured. It is possible in these cases to secure restoration of nerve and tendon function. Careful work determines the difference between a result with a useful hand and one with a useless hand.

THE AXILLA

Wounds of the Axilla.—The serious feature in wounds of the axilla is that injury to important nerves and blood-vessels may be still further complicated by wounds of the thorax or shoulder-joint. In these complicated conditions the surgeon must recognize and treat each injured structure separately, the urgent condition receiving first attention. Wounds of the axillary artery are very serious. If there is a wound through which it may be reached, pressure may be made or the vessel clamped. This is rarely possible, and it becomes necessary to make pressure on the subclavian artery as it passes over the first rib. In most cases it will be found expedient to make pressure in the axilla, compressing the vessel against the upper end of the humerus, while the subclavian artery is exposed and ligated. It is usually easier and safer to ligate the subclavian artery through a clean surgical wound, than it

is to find and ligate the wounded axillary artery through a mass of clots. The danger of injuring the nerve trunks in the axilla must always be considered.

Wounds of the axillary vein are very serious. If there is a wound through which the vein may be compressed or clamped it may be controlled directly. If this can not be done, ligation of the subclavian artery is the operation of choice.

Wounds of the axilla in which injury of the great vessels is present are apt to be accompanied by injury of the nerve trunks. A testing of the nervous reactions of the arm should be made to determine whether nerve injury is present. Suture of divided axillary nerve trunks is often required (see Nerves of Upper Extremity, Vol. I, page 892; and Vessels, Vol. I, page 415).

Abscess of the Axilla.—Suppurating lymph-nodes or other infections may give rise to abscess. This should be opened promptly in order to minimize the amount of connective-tissue deposit. Such abscesses often lie in close relation to the axillary vessels and nerves, and their treatment must be with consideration for these structures (see Axilla, Vol. I, page 415).

Tumors of the Axilla.—On account of the vessels and nerves, the removal of tumors of the axilla is often a matter of careful dissection. When the growth involves the axillary vessels and nerves so that they must all be sacrificed in its removal, amputation of the arm is to be preferred to leaving a paralyzed and possibly gangrenous member. In an otherwise healthy patient, before resorting to amputation plastic operation upon the nerve trunks, to restore their continuity, should be attempted.

It is possible for the arm to live after ligation of both the axillary artery and vein in a healthy person. In a debilitated or aged person gangrene may be expected to follow ligation of both of these vessels.

THE HAND AND FINGERS

Disturbances of Motion Due to Ankylosis and Contractures.—(See Joint Contractures, Vol. I, page 682; Ankylosis, Vol. I, page 757; and Operations on Joints, Vol. I, page 737). Much can be done for these conditions. The stretching and division of soft parts with the application of skin grafts offer help. In ankylosis, the resection of joints and the interposition of soft tissue to prevent bony reunion can be done in small joints as well as in large joints.

Neuropathic Contractions.—These are to be cured by treating the nervous cause. Later attention to the local condition may be required.

Ischemic Muscular Paralysis.—This condition which is seen most commonly in its distressing effect upon the hand, should be prevented by avoiding too tight bandaging. It should be recognized as soon as it threatens. A bandaged arm should always be watched for this condition, the surgeon bearing in mind that pain is not always present. After loosening the bandage the nutrition of the part should be improved by the use of passive motion, massage, hot applications or electricity. Exercise, combined with the above measures should be persisted in to restore the nourishment and function of the muscle and to prevent contractures from its atrophy. The galvanic current should be used while reaction of degeneration is present. As soon as the muscle responds to faradic electricity, it should be employed.

To prevent contractures and deformity, the joints operated upon by the atrophied muscles should be placed in such a position that the atrophied muscles are relaxed and the opposing healthy muscles put on the stretch.

This aims to prevent the healthy muscles from contracting and causing deformity.

In the course of time when it is found that the muscle is irrecoverably damaged, plastic operations upon the tendons may be done. The tendon of healthy muscle may be sutured to the tendon of the diseased muscle to do its work (see Ischemic Degeneration of Muscle, Vol. I, page 793).

Contracture of Palmar Fascia (Duypuytren's Contracture).—This spontaneous contracture of the palmar fascia which results in flexion of the fingers, is best treated by operation. The palmar fascia, which is at fault, consists of a central portion and reflections to the fingers. Two lateral reflections cover the muscles of the thumb and little finger. The longitudinal fibers are continuous with the palmaris longus tendon and the annular ligament.

FIG. 1842.—OPERATION FOR CONTRACTURE OF PALMAR FASCIA.
Showing incisions for dissecting out the contractured scar tissue.

Four processes pass to the fingers to be attached to the digital sheaths, to the skin at the finger clefts, and to the superficial transverse ligament. Prolongations of these processes pass to the sides of the fingers to be attached to the periosteum and to the tendon sheaths of the two proximal phalanges.

Removal of the contractured fascia gives the best results. This is done by turning back a palmar skin flap with its base upward. Longitudinal incisions expose the fascia of the fingers, so that all of the contractured fascia is exposed (Fig. 1842). Then the contractured fascia should be excised. This may require removal of some of the skin to which the fascia is attached. After removal of the fascia, a sliding skin flap from an adjacent part of the hand may be required to complete the covering of the wound. It should all be covered with skin, carefully sutured in place. The hand and fingers should be put up in slight flexion.

If the fascia is so closely attached to the skin that a viable flap cannot be secured, and a comparatively large area of skin must be removed, the area may be covered by a reversed flap taken from the chest or thigh, the hand being bound to the chest or thigh until it has become attached.

If the area of contracture is small, a flap need not be turned back, but the fascia may be exposed by a longitudinal incision, the skin dissected free on either side, and the fascia excised.

Another method of treatment consists in making subcutaneous transverse divisions of the contracted fascia and putting the hand up with the fingers

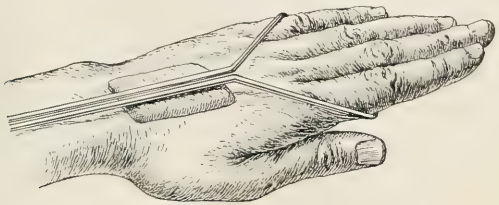


FIG. 1843.—APPARATUS FOR EXTENDING FINGERS.

extended. The injection into the contracted fascia of fibrolysin has given results which have been reported as satisfactory to some surgeons.

A splint, provided with elastic compression or a spring which holds the fingers in extension, is useful for treating mild cases and controlling the hand after operation. Such a splint may easily be extemporized. Considerable pressure may be employed providing that adequate padding protects the skin. Simple wooden splints may be used, anteriorly and posteriorly, and held together with elastic rubber bands. A celluloid, leather, or metal apparatus may be applied (Fig. 1843).

Claw-hand (Griffin Hand, Main en Griffe).—This condition, due to paralysis of the ulnar nerve, is remedied only by restoring the function of the nerve. The divided nerve should be sutured. If in doubt, after two weeks, if there is complete reaction of degeneration the nerve should be exposed and sutured. If the nerve has not been divided but paralysis persists, the nerve should be exposed, freed from compression, stretched, or otherwise relieved.

Writers' Cramp.—This contracture of the flexor muscles of the arm and hand, involved in holding a pen, and caused by over-use of the muscles is best treated by rest. If the impulse to write cannot be assuaged, a ring with a clip may be fitted over the end phalanx of the index-finger, and the clip caused to carry the pen. This relieves the flexors of the index-finger of the necessity for contracting to hold the pen. If necessary a similar device may be applied to the thumb. Massage of the fingers, hand, and forearm is of help.

FIG. 1843a.—INCISION FOR DROP-FINGER.
Through this incision the extensor tendon is shortened.

Mallet-finger (Hammer-finger, Drop-finger).—When the extensor tendon is torn from its insertion into the dorsal surface of the last phalanx, as often happens as a result of even slight violence, complete extension of the terminal phalanx is not possible until the extensor tendon is reattached to the bone.

If seen immediately after the injury which causes the tearing loose of the tendon, the phalanges, hand, and wrist should be put up on a splint in a position of overextension, with the hand supinated, with the view of relaxing the injured tendon as much as possible. This position should be maintained for two weeks, being relaxed somewhat, if it becomes uncomfortable. If the drop-finger is not cured by this treatment, operation offers a cure. This consists in making a Y-shaped incision just above the root of the nail, exposing the extensor tendon, and sewing it fast to the dorsum of the last phalanx (Fig. 1843*a*).

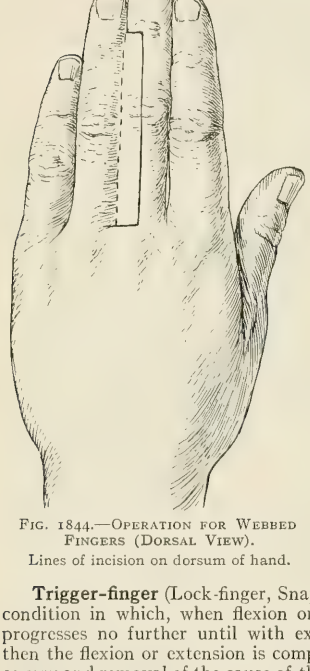


Fig. 1844.—Operation for Webbed Fingers (Dorsal View).
Lines of incision on dorsum of hand.

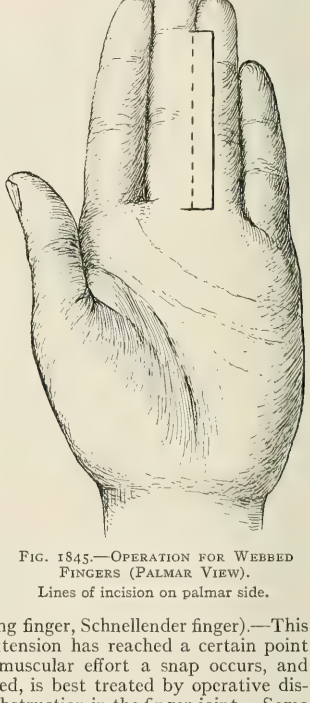


Fig. 1845.—Operation for Webbed Fingers (Palmar View).
Lines of incision on palmar side.

Trigger-finger (Lock-finger, Snapping finger, Schnellender finger).—This condition in which, when flexion or extension has reached a certain point progresses no further until with extramuscular effort a snap occurs, and then the flexion or extension is completed, is best treated by operative discovery and removal of the cause of the obstruction in the finger-joint. Some obstacle to free motion will be found in cases which have not yielded to rest.

Webbed Fingers (Syndactylism).—In the cases in which the phalanges are present and there is a web connecting the fingers, the operation credited to Didot is recommended. An incision the length of the web is made on the dorsum of one finger, and across the web at its top and bottom, and a quadrilateral flap dissected back. Another incision is made the length of the other finger on its palmar surface, and transverse incisions from each end of

this and a palmar flap dissected up (Fig. 1844). The dissection of these two flaps splits the web and makes a flap for covering the raw surface of each finger. The flaps are sewed in place by fine thread (Figs. 1845 and 1846).

In cases in which there is imperfect development of the bones, a plastic operation, or a series of operations, may be done to separate the fingers and reconstruct the imperfect members. The object of most of these operations is to secure a cosmetic result; therefore the amputation of an unsightly finger is often desirable when its reconstruction is impossible. The radiograph is an aid in determining the procedure in these cases.

Supernumerary Fingers (Polydactylism).—The treatment of this condition is largely cosmetic. In the case of a rudimentary digit, loosely attached, or a more or less well-developed digit, articulating with the side of a metacarpal or phalangeal bone, removal of the extra digit is called for. Such a digit has no function and is to be regarded much as a tumor. In

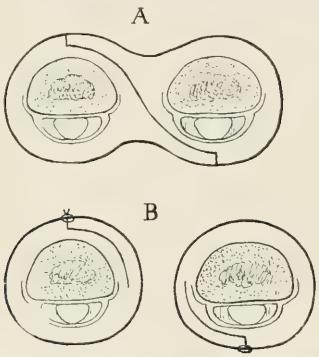


FIG. 1846.—OPERATION FOR WEBBED FINGERS (TRANSVERSE SECTIONS).
A, Lines of incision; *B*, flaps sewed in place.

the case of a well-formed, functionating digit, having a metacarpal bone of its own, or articulating with a metacarpal bone in common with another digit, amputation is not so desirable. In such cases, it is possible that the resulting scar and ill proportion of the hand after amputation may look worse than the extra digit. Removal of the sixth metacarpal bone, or its head, is usually a necessary part of such a cosmetic operation. As the presence of supernumerary fingers may be interpreted as stigmata of atavism, most people will desire to be rid of them.

Contractures of Fingers.—(See Contractures of Joints, Vol. I, page 682, and Contracture of Palmar Fascia, above.)

Congenital Deformity of the Arm.—This condition when due to absence of bone, shortening of bone, fusion of bones, or bony distortion may be remedied by plastic operation. The surgeon must decide what the patient is suffering from, what he needs done, and then consider the mechanical possibilities of doing it. Amputation of even a badly deformed arm is not to be considered (see Plastic Operations on Bones and Joints, Vol. I, page 688).

Subungual Hematoma.—Hemorrhage under the *nail* is best treated by trephining the nail over the clot and liberating the blood. This causes no pain; it relieves pain, saves the nail and hastens healing.

Restoring Amputated Fingers.—It is possible after the amputation of a finger to sew it back in place and secure its revivification. This is only possible when a comparatively clean wound can be had, and when the finger has not been detached long enough to have undergone serious disorganization of its proteid substance. The amputated finger should be cleansed in warm salt solution. The deep fascia and the flexor and extensor tendons should be sutured. The skin should then be sewed.

In these cases it is possible to make an incision at the tip of the finger down to the bone, apply suction apparatus to the restored part, and draw blood through its vessels (see below). Fingers from the hand of one person may thus be transferred to the hand of another.

In cases of loss of the end of a finger, cutting off the soft parts on a level with the bone, a plastic operation to cover the end of the bone with healthy tissue is usually done if it is desired to save the bone. If this is not done, enough bone is removed to allow the soft tissue to cover what is left. J. S. Davis (Jour. Am. Med. Assoc., May 15, 1915) applied a tube of celluloid to the end of the finger, extending a short distance beyond the stump. Into this granulations grow and cover the end of the bone with a thicker covering of connective-tissue growth than can be secured by a simple dressing. This new tissue naturally tends to contract, and is not as good as a transplanted flap of skin and subcutaneous tissue.

Plastic Reconstruction of Fingers.—After complete loss of the right thumb, Noesske (Fortschritte der Medizin, Apr. 30, 1909) reconstructed a new thumb from a pedunculated skin flap from the chest. The patient was a boy of thirteen. The flap was given three weeks to become well attached to the hand before the pedicle was cut. A new thumb was thus made of skin and subcutaneous tissue. After it was well healed, it was incised and a piece of bone from the tibia was introduced. This grew fast to the first metacarpel bone in two or three weeks. Sensation in the new thumb became nearly normal. The patient was able to use the new digit with good effect. Noesske intended later to transplant the nail from a toe to complete the work.

It is entirely possible in such cases to attach the flexor and extensor tendons to the new bone, to reconstruct a joint, and proceed indefinitely with plastic operations, until a new and effective finger has been created (see Osteoplastic Operations, Vol. I, page 786).

To Prevent Gangrene of Fingers.—After injury to fingers, frost-bite, Raynaud's disease and thrombosis, Noesske (Zentralblatt für Chirurgie, Oct. 2, 1909) showed that the arterial blood is prevented from entering the vessels by the venous stasis caused by thromboses, and collapse of the veins. The tissues may be preserved from decay if arterial blood can be brought promptly into contact with them. He has shown that this can be done by making an incision down to the bone at the finger-tip, tamponing the wound with gauze soaked with camphorated oil to prevent closure of the wound, and then applying suction. With a suction bell maintaining a vacuum with a negative pressure of 12 to 15 cm. of mercury, 2 or 3 times a day, for eight or ten minutes at a time, continuing the treatment for about a week, arterial blood is drawn into the tissues until viability is assured. The suction alone does not suffice, the incision is most important. Experience thus far has been limited to fingers, but it is suggested that the same principles may be applied to tissues elsewhere.

In threatened gangrene of the extremities from arteritis, the extremity may be placed in the suction apparatus and circulation restored. Hot applications, either in the form of moist heat or dry heat, are also effective.

THE PELVIS

Wounds of the Pelvis.—These wounds are important because of the possibilities of complicating injuries to pelvic organs (see Wounds of Bladder, Ureter, Urethra, Uterus and Rectum; for Fractures of Pelvic Bones, see Vol. I, page 582).

Injury of the Sacro-iliac Joint.—*Relaxation of the sacro-iliac joint*, occurring as a result of injury, following childbirth, or appearing in weak and flabby people, requires first improvement of the general health. Rest, support and immobilization of the joint are the essentials of treatment. In the acute cases rest in bed is necessary. In the chronic cases a period of recumbency is desirable. In all cases help will be had from the use of fixation apparatus. Acute and severe chronic cases are best treated by applying a plaster-of-Paris jacket tightly around the pelvis, sacrum and hips. Afterward, a corset of leather or other firm material should be used. It will be found that in many of these cases there is a loss of the normal lordosis of the lumbar region, and the sacrum has a position nearer the perpendicular than it should have. This is to be overcome by restoring the forward curve of the lumbar spine by means of a brace which at the same time fixes the pelvis and sacrum, and makes inward pressure on the thighs. Some form of counterirritation to the skin, such as the actual cautery, over the sacro-iliac joint, is useful in improving the circulation, inducing local hyperemia, and in relieving joint pain.

In the extreme type of relaxation of the sacro-iliac joint, shortening of the posterior ligaments, by chiseling loose the iliac attachment and sliding it outward has been recommended; and in cases not yielding to this treatment, destruction of the joint, and the induction of bony union between sacrum and ilium, has been employed.

Pelvic Abscess.—Pelvic abscess, springing from disease of the pelvic bones or connective tissue, and not from the genital organs, spine or other sources already considered, requires the same treatment as abscess in other parts. In all nontuberculous cases the pus should be evacuated through the channel where the best and safest drainage can be secured. This may be through the skin of the groin, thigh or other pelvic region, through the vagina, rectum or abdomen. In these abscesses of pelvic bone origin, it is desirable to operate as near the source of the disease as possible. Often a localized necrosis of bone will be found and a sequestrum may require removal (see Osteitis, Vol. I, page 688).

The **presacral abscess,** of bone or connective-tissue origin, may appear posteriorly or find its way at the side of the rectum. Early and free evacuation and rapid healing should be secured because of the danger of the development of scar tissue, involving the sacral nerves, and the subsequent distressing symptoms which it is capable of engendering.

Lymphadenitis of the Groin.—In subacute and chronic infection, when not of tuberculous or venereal character but due to the ordinary pus-producing organisms, the inflamed glands if actually infected are best treated by removal. This treatment is indicated in cases in which the tumor does not subside after rest in bed for a week.

The treatment of lymphadenitis of the groin, associated with gonorrheal

urethritis (*bubo*), should be rest in bed. The local application of tincture of iodin, ichthyol ointment, or mercurial ointment is a routine treatment probably of little value. Hot applications may be of service. Cold applications relieve pain in some cases. Cure of the urethral infection is important. A spica bandage to the groin making pressure through a firm pad, in some cases gives relief and hastens the absorption of the bubo.

Bubo which persists or which goes on to suppuration is best treated by puncture, evacuation and iodoform emulsion injection.

Operation consists in dissecting out the enlarged glands. This is done through an oblique incision parallel with Poupart's ligament. Usually the glands can be removed in one mass. Operating upon a large number of these cases in soldiers in the U. S. Army, I found that prompt operation, before suppuration had developed, greatly shortened the period of invalidism. If operated upon early the wound could be closed throughout most of its extent, and healing by primary intention secured. The objection to this operation is that it cuts off the lymph channels and may be followed by chronic lymphedema of the scrotum and penis. It is not to be recommended as a routine procedure.

The *bubo* of *chancroid* should be treated by rest. The disease is prevented by early local and hygienic treatment of the chancroid. The methods above described are all applicable. Some surgeons employ the tentative measures in all cases of bubo; when suppuration occurs, the pus is drawn off through an aspirator or a small puncture, the cavity is washed out, phenol injected and washed out with alcohol, and the cavity filled with 10 per cent. iodoform in glycerin or warm iodoform ointment. The injection should be made 2 or 3 times at the first sitting to wash out the cavity. The emulsion should be squeezed out on the following day and re-injected. If it is not healed in a week it should be injected again.

If the bubo is permitted to suppurate and the abscess is freely incised and packed, the resulting wound requires a long time to heal. Dissecting out the enlarged glandular mass is objectionable because it is apt to cause chronic edema of the scrotum and penis. The treatment which is free from both of these objections is the primary nonoperative treatment followed by aspiration and antiseptic injection if abscess forms.

Tumors of the Pelvis.—The treatment of tumors developing within the pelvis is discussed under the various appropriate heads. Tumors of the pelvis proper may be removed even though an extensive sacrifice of the bone is necessary. Sarcoma of the pelvis involving the acetabulum has required sacrifice of the limb and extensive resection of the pelvis. Up until 1912 only 7 of the 24 patients on record, upon whom an interileo-abdominal amputation had been done, had survived longer than a few days after the operation. Since those operations, the use of abdominal constriction (Momburg) has greatly lessened the loss of blood during the operation (see Vol. I, page 363). Several cases have been reported in which abdominal constriction was employed to prevent bleeding, and most gratifying results were secured. This technic is applicable in all extensive pelvic operations. It has been employed with good results in extensive resection of the pelvis without disarticulation of the thigh.

In *tumors of the sacrococcygeal region*, the growth is often of teratomatous origin—often there is a sinus running back to the sacrum or within the pelvis—and unless the growth is followed to its furthest penetration, recurrence may be expected. Dermoid cysts developing between the rectum and sacrum require removal by resection of coccyx and sacrum after the methods employed in approach to the rectum for tumor of that viscus. *Sinuses of the*

sacrococcygeal region are commonly of congenital character and are cured only by being dissected out or having their lining epithelium destroyed. *Ano-sacral cysts*, originating from remains of the postanal gut and neurenteric canal, are cured only by being completely dissected out or by having their epithelial lining destroyed.

Strains of the Sacro-iliac Joint.—In many of these cases only one side is affected. The patient should have rest in bed with a tight adhesive strap around the pelvis. The more severe cases require a well-fitting jacket of plaster-of-Paris, or lighter material, so constructed that a girdle makes pelvic pressure. These measures failing, operative treatment should be done to produce ankylosis of the joint (see Diseases of Sacro-iliac Joint, Vol. I, page 651; see also Relaxation of Sacro-iliac Joint, above).

Epidural Injections for Sacral Pains.—In cases of pains of the sacral region, not due to discoverable pelvic disease, notable relief has been secured by the injection of 30 to 40 c.c. of physiologic salt solution in the subarachnoid space of the lumbar cord (see Spinal Anesthesia, Vol. I, page 155.) After the cure of disease of the uterine appendages, persisting sacral pain has been cured by this method.

Epidural injections in pelvic disease of various characters have proved effective. In functional bladder disturbances, pruritus vulvæ of unknown origin, coccygodynia, enuresis, and functional neurosis in the abdominal and pelvic organs without definite pathological findings, treatment with saline injections (30 to 40 c.c.) in the epidural space has proved effective. In some cases repetition of the treatment has been necessary (see Epidural Injections, Vol. I, page 162).

THE LOWER EXTREMITIES

Fractures, inflammations and **tumors** of the femur, patella, tibia, fibula, tarsal bones, metatarsal bones, and phalanges are discussed in the chapters on Diseases of Bones, Operations on Bones and Joints, and Tumors.

Dislocations of the hip-joint, patella, knee, tibiofibular joints, ankle, tarsal, tarsometatarsal, and phalangeal joints are discussed in the chapter on Dislocations.

Injuries and **diseases of blood-vessels** are discussed in the chapter on Blood-vessels.

Injuries and **diseases of nerves** are discussed in the chapter on Nerves.

THE HIP

Contusions of Hip-joint.—Rest in bed is the best treatment for these injuries. If there is much traumatic arthritis, an immobilizing splint should be applied. If pain persists, the same splints as are employed in tuberculosis are of service. It should be borne in mind that persisting synovitis, especially in the adolescent or adult, unless it is undoubtedly the result of injury, is apt to be tuberculous.

Acute Suppurative Arthritis.—This condition should be treated by early incision of the joint, free drainage and rest. Unless this is done, necrosis of the head of the femur is apt to develop, and be followed by dislocation. Drainage is secured by inserting a rubber tube (see Arthritis and Operations on Hip-joint, Vol. I, pages 657 and 748).

Arthrotomy of Hip-joint.—To open the hip-joint for drainage or other purpose an incision similar to that for resection of the joint is employed. The arthrotomy incision should be shorter. Any of the incisions for excision may be followed, that part of the incision being used that lies nearest to but not on the great trochanter. For arthrotomy for drainage the incision need not be more than 2.5 cm. (1 inch) long, and lie directly behind or above the great trochanter. A shorter incision may be made and the drainage accomplished by making a puncture with a straight knife or a trocar and canula. Arthrotomy for foreign body requires a longer incision than for drainage. After a clean operation the joint should be closed. Immobilization should follow in any case (Vol. I, Arthrotomy, page 748; and Immobilization, page 583).

Subacute and Chronic Arthritis of the Hip.—These conditions are best treated locally by an immobilizing splint, and by attention to any causative constitutional derangement.

Spontaneous Dislocation of the Hip.—Occurring as a result of disease of the joint, destroying some part of the ligaments, this accident should be prevented by evacuating fluid before it has distended the joint. When disease has occurred the danger of the accident may be diminished by preventing flexion, abduction, and outward rotation of the thigh, as it is in these positions that dislocation is apt to occur.

When dislocation has taken place, if drainage of fluid is still necessary, it should be provided. Necrotic material should be removed. The bone

should be replaced as soon as possible to prevent its fixation by adhesions. The joint should then be fixed by a splint. In old cases in which the femur has become fixed in a false position, the joint should be exposed as for resection, necrotic material and plastic deposit in the joint removed, and reduction effected (see Resection of Hip-joint, Vol. I, page 748). Later osteotomy may be required to correct bad position.

Dislocations of the congenital type and dislocations due to relaxation of the ligaments are best treated by operation (see Dislocations, Vol. I, pages 613 and 783).

Deforming Osteochondritis of the Hip of Children.—This disease, characterized by a progressive destruction chiefly of the upper femoral epiphysis, causing slight limp and limitation of abduction, tends to self-healing. Treatment should consist in correction of the defective abduction under general anesthesia. This should be followed by traction extension to take the pressure from the joint. Massage should be applied to the thigh and hip muscles.

Arthritis Deformans.—In the hip, this condition in some cases leaves exostoses the removal of which will allow of better motion of the joint. But so long as the disease remains constitutional no such operation is to be advised.

It is most important to relieve pain by rest in bed. Traction is often of help in protecting the joint, and is indicated when passive motion is painful and is restricted by muscular spasm. The traction should be applied as for tuberculous disease of the hip. Two or three kilos (5 pounds) of extension are adequate. Two to six weeks of this treatment relieves pain and joint irritability, and should be followed by an immobilizing hip splint such as is employed in tuberculosis. The patient should be up and about with crutches. Vibratory massage or high-frequency electricity may be employed (see Arthritis Deformans, Vol. I, page 661).

Operation offers help in aggravated cases. Resection of the head of the femur is of doubtful utility. Exposure of the joint and interposition of a layer of fascia between the head and acetabulum have been tried with some success. Arthrodesis is a useful operation. This should be done without disarticulation. A segment of the upper part of the head of the femur and a section of the upper floor of the acetabulum are chiseled out (see Arthroplasty, Vol. I, page 738).

Loose Bodies in the Hip-joint.—The most common loose body requiring treatment in the hip-joint is the detached head of the femur. Cartilaginous bodies and foreign bodies sometimes require removal. Access to the joint is secured by the arthrotomy incision described above (Vol. I, page 748).

Contractures at the Hip-joint.—Contracting deformities at the hip are to be treated by the methods already described for contractures in other joints (page 682). Stretching of soft parts, division of resisting structures, and osteotomy of the femur are the operative expedients.

Ankylosis of the Hip.—Ankylosis of the hip in an old person, if in a position which allows good locomotion, need not be treated. For the young and middle-aged something should be done. Bad position is corrected by osteotomy of the femur. Plastic operation for restoring mobility is a most effective procedure (see Operations on Joints, page 765).

Coxa Vara.—This deformity should be prevented by sparing children with weak or diseased femoral necks the necessity for long standing. Exploited child labor should be abolished. The conditions predisposing to rachitis should be removed. A better range of motion may be secured by massage and passive and forcible movements. In the case of a unilateral deformity,

a hip splint, such as is used in the later stages of tuberculosis, may be employed to take the weight of the body away from the hip until the fundamental disease can be cured. Coxa vara cannot be cured by treatment other than operative; operation must be done unless it is contraindicated.

Operative treatment is indicated in most cases—at least in those in which the deformity produces a decided limitation of motion, shortening, and limp. When the bone is soft forcible abduction may be of help. The thigh is put up in this position in plaster-of-Paris. Subtrochanteric osteotomy is of value in cases with outward rotation. The thigh is rotated, abducted and fixed, and allowed to heal in corrected position. Cuneiform osteotomy is indicated in cases in which outward rotation is not extreme. A wedge of bone with

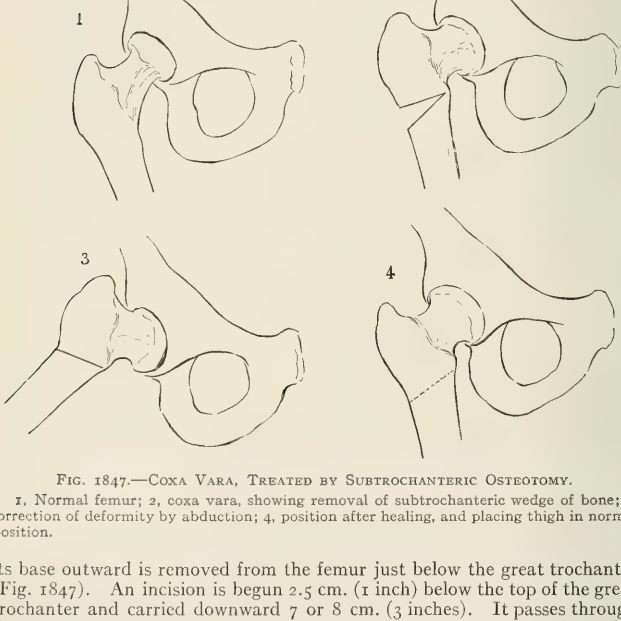


Fig. 1847.—Coxa Vara, Treated by Subtrochanteric Osteotomy.

1, Normal femur; 2, coxa vara, showing removal of subtrochanteric wedge of bone; 3, correction of deformity by abduction; 4, position after healing, and placing thigh in normal position.

its base outward is removed from the femur just below the great trochanter (Fig. 1847). An incision is begun 2.5 cm. (1 inch) below the top of the great trochanter and carried downward 7 or 8 cm. (3 inches). It passes through the periosteum, which is then to be separated from the bone. The wedge should be opposite the lesser trochanter. Its base should be about 2 cm. (¾ inch) wide. It is well to determine the size of the wedge, by making a paper model from an *x*-ray picture. The wedge having been taken out, the shaft is abducted until the opening is closed by the two cut surfaces coming together. The lesser trochanter strengthens the bone at the apex of the wedge. The bone is then fixed by a plaster-of-Paris splint, including the pelvis and foot, holding the thigh in abduction for about eight weeks until

solid union has been secured. When consolidation has taken place, manipulation, massage and passive motion are employed to overcome contractures of the soft structures and bring the thigh into normal position. This operation gives admirable results.

This same treatment is applicable to fractures of the neck of the femur which have healed with depression of the neck.

Coxa vara of adolescence, sometimes called "false coxalgia," due usually to defective growth of the bone, should be treated first by relieving the neck and the femur of pressure. Long-standing should be prevented. Arthritis, if present, should be treated by rest and traction. If there is no inflammation and abduction is much limited, subperiosteal, resection of the great trochanter may be done. Subtrochanteric or cervical osteotomy and fixation of the limb in a position of abduction may be required in aggravated cases.

Coxa Valga.—This rare condition, with elevation of the neck of the femur, is treated by osteotomy of the neck and correction of the deformity. Two principles are available; the normal neck-shaft angle may be restored by osteotomy, adduction, and fixation; or osteotomy of the neck may be done and the trochanter simply allowed to slip upward. The latter has been employed most successfully. Subtrochanteric osteotomy may be done in some cases.

Snapping Hip.—This condition, characterized by the hip-joint slipping around with an audible snap upon flexion and extension of the joint, usually due to a slipping of the iliotibial band over the great trochanter, is remedied by sewing the band to the femur behind the trochanter or the gluteus maximus. Another measure which has given relief has been sewing the obstructing band, which may be the anterior edge of the gluteus, to the insertion of the vastus externus. Those cases in which the snapping is due to a deficiency of the posterior border of the acetabulum, are to be treated by creating a higher border either by chiseling up a rim of bone and periosteum or by implanting a graft of bone.

THE KNEE

Hyperplasia of Fatty Tissue in the Knee-joint.—The fatty pad lying in connection with the ligamentum mucosum, when inflamed, may be relieved by rest. Repeated attacks of disability call for removal of the offending tissue. This may be done through an incision on either side of the patella.

Hypertrophy of the Synovial Fringes of the Knee-joint.—The synovial fringes lying back of the patella require surgical attention when they become so much hypertrophied that they interfere with the movements of the joint by becoming engaged between the tibia and femur when the leg is extended. An incision is made on either side of the patellar tendon. These incisions are carried down to the capsule of the joint but not through it. The capsule is then exposed for an area of 5 cm. (2 inches) in diameter. A longitudinal fold of the capsule is lifted up with forceps and drawn out as far as it can be. This fold is then cut off beyond the suture line and the raw edge stitched over-and-over with a running suture. Chromic catgut is used. This is done on either side of the patella. The wounds are closed, and the knee immobilized with a splint for ten days. After this the knee may be used.

Bursitis.—*Prepatellar bursitis* has been described (Vol. I, page 819). *Pretibial bursitis*, between the ligamentum patellæ and the tibia, may be relieved during its acute stage by immobilizing the knee with a splint. If the condition becomes chronic, thickening of the bursa, with pain and tenderness persisting, removal of the bursa is called for. If this is not done some relief may be secured by snug strapping of the front of the knee with adhesive strips.

Genu Recurvatum.—This congenital condition, in which the knee is bent backward, is treated by massage of the atrophied, muscles and forcible stretching of the contracted structures. Anesthesia and forcible correction may be required in extreme cases. Relaxation of the ligaments may call for a light hinged brace, whereby the child may begin the use of the limb. This may be left off as the parts become stronger.

Elongation of the Patellar Ligament.—This condition is best treated by chiseling off the patellar tubercle of the tibia and sliding it down upon a lower freshened surface of bone where it may be held by sutures. The result is treated as a fracture.

Congenital Relaxation of the Knee Ligaments.—This condition is best treated by support in a corrected position and massage of the weak parts. Usually a flannel bandage suffices for fixation. Rarely will a hinged brace be required, allowing motion only in the anteroposterior directions.

FIG. 1848.—BOW-LEGS.
Type of case which will correct itself in time without operation or other treatment.

Painful enlargement of tuberosity of tibia in growing children, probably due to injury, is to be treated by immobilization of the knee and a restriction of activities until a cure is secured.

Bow-legs (Genu Varum).—Children under three years of age with slight outward bow-legs require no treatment; the deformity is commonly the result of diapers or too early standing, and is gradually outgrown (Fig. 1848). In these moderate cases, after diapers are discontinued, correction may be hastened by gently pressing the knees together twice daily.

In children up to four years of age with aggravated outward bow-legs, a metal brace, hinged at the knee, should be worn on the inside of the legs, and the leg strapped so that the knee is drawn toward the splint (Fig. 1849). Such a brace should allow free use of the leg. About six months of treatment usually suffice to effect a cure. If the deformity is especially in the lower part of the tibia a brace consisting of an inner bar is used. The upper end presses against the condyles at the knee, the lower end is made fast to the shoe. A knee and ankle pad are introduced. The curved tibia and fibula are laced toward the bar. For curvature at the knee the brace devised by C. D. Napier is to be recommended. It consists of an inner bar which extends from the shoe to the upper third of the thigh. A thigh band connects it to the shorter outer bar lying along the upper third of the thigh. The inner bar is provided with a canvas flap for lacing whereby the curved knee is drawn toward the bar.

By putting up a child's leg in an immobilizing splint or in plaster-of-Paris for four weeks, the bones lose much of their mineral constituents, and are easily bent. This principle may be made use of in some of these cases. It should always be borne in mind in dealing with deformities of bone in children.

Operation for bow-legs is indicated in children over four years of age. If done before this, recurrence of the deformity is apt to take place.

Osteoclasis is one of the methods employed. It is indicated only in children, and then only in cases in which the curve is not at the knee. In young children the bone may be bent forcibly by the hands to the point of produc-

ing a green-stick fracture or a complete fracture. The osteoclast may be used provided it does not operate upon the knee, where it might cause strain of the ligaments.

Osteotomy is the operation of choice in adults and in curves near the joint. Linear osteotomy is to be preferred to cuneiform osteotomy except in extreme curvature of the tibia (see Operations on Bones, Vol. I, page 688).

The best operation usually adapted to these cases is osteotomy with the small osteotome inserted at the inner side of the tibia at the place of greatest curvature. When the bone has been cut sufficiently the fracture is completed by manual force. The fibula in children usually requires no attention as it bends with the tibia. In adults it may require osteotomy. The deformity should be slightly overcorrected. A plaster-of-Paris case should be applied from the toes to the trochanter. The patient may be allowed to stand on the leg after a few days of rest in bed. There is no discomfort. The splint is left on about six weeks. If slight overcorrection has been made no apparatus need be worn after the splint is removed. In some cases a brace is required for a few months.

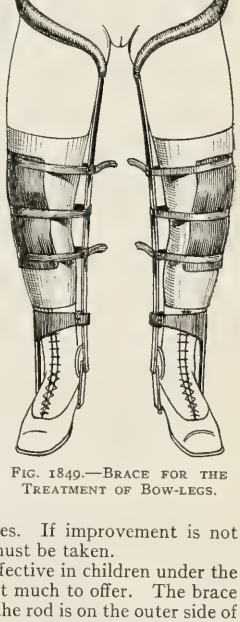


FIG. 1849.—BRACE FOR THE TREATMENT OF BOW-LEGS.

It will be noted that in most cases of bow-legs there is deformity of the femur as well as of the tibia. Most cases are cured by correcting the greater distortion which is in the tibia. In extreme cases osteotomy of the femur also is required. The two osteotomies may be done at the same operation or at two sittings (see Osteotomy, Vol. I, page 711).

Knock-knee (Genu Valgum).—This condition in a moderate degree in young children should be treated by gently bending the legs toward a normal position twice daily to encourage correction. Improvement of the general health, and the removal of causes, such as defective positions in standing, are important. Flattening of the arch of the foot is one of the dangers of this deformity, and should be counteracted by placing a lift on the inner side of the sole of the shoe to raise the inner side of the foot about 6 mm. (¼ inch). These methods are all that are required in mild cases. If improvement is not secured by these means, more active measures must be taken.

Mechanical treatment by means of braces is effective in children under the age of four years. After the fifth year it has not much to offer. The brace is similar to that used for bow-legs except that the rod is on the outer side of the leg and has no joint at the knee. The brace should hold the leg in extension as the deformity is greatest when the knee is extended (Fig. 1850). The upper end of the bar should have a pad to press against the trochanter and the lower end should be turned in and attached to the heel of the shoe. The knee should be drawn backward and securely attached to the brace by an elastic bandage or flap. The braces should be removed twice daily and the legs moved and treated by massage. The braces need not be worn at night unless for some reason haste in the cure is necessary. They should be

worn until slight overcorrection is secured. This requires six to twelve months.

Instead of braces some surgeons have preferred to use plaster-of-Paris, correcting the deformity as far as possible and then putting the limb in plaster bandages. This procedure is repeated at intervals until full correction is secured. Or the correction may be done completely at one operation under general anesthesia, and the limb encased in plaster dressing.

Operative treatment is the procedure of choice after the age of four or five years. Osteotomy of the lower end of the femur is the operation of choice. The operation of Macewen is best adapted to most cases (see Operations on Bones, Vol. I, page 711). In cases in which the deformity is mostly in the tibia, linear osteotomy of the tibia is best; and in older patients osteotomy of the fibula is also necessary. Both legs may be operated upon at one sitting. After the osteotomy the leg should be put up in plaster-of-Paris from the toes to the trochanter, in a position of slight overcorrection. It is necessary that the child should be kept in bed but a few days. There should be no discomfort. After that it may be allowed to stand and walk. About six weeks should be allowed for solid union. After that a brace should be worn for a few months while massage and passive motion are practised twice daily.

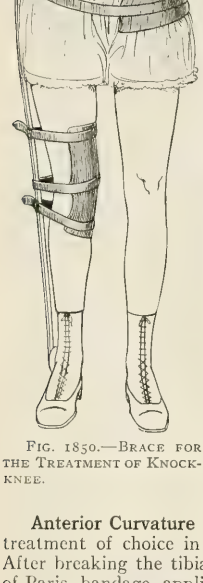


FIG. 1850.—BRACE FOR THE TREATMENT OF KNOCK-KNEE.

The operation of *osteoclasis* may be performed in exceptional cases when it can be done without injury to the joint. Injury of the perineal nerve has occurred in a number of cases. The operation should be done by placing the lower resisting bar over the external condyle and the other bar 10 cm. (4 inches) higher. *Epiphyseolysis*, breaking loose of the lower epiphysis of the femur and displacing it inward, has been much favored by some European surgeons. Codivilla has reported some 1000 cases without a single instance of disturbance of growth of the bone (Bulletino Dell. Sci. Med. di Bologna, v, 1905).

In cases in which the principal deformity is in the tibia, correction should be made in that bone. Often both femur and tibia are distorted, in which cases both should be operated upon.

Anterior Curvature of the Tibia (Anterior bow-legs).—Osteotomy is the treatment of choice in most of these cases. Osteoclasis is also effective. After breaking the tibia and fibula the deformity is overcome and plaster-of-Paris bandage applied from the toes to the middle of the thigh. Tenotomy of the tendo Achillis may be necessary.

THE ANKLE, FOOT, AND TOES

Infections of the Foot.—The treatment of infections of the foot should be carried out in the same manner as the treatment of infections of the hand (see page 444).

Such infections may be associated with corns, bunions, ingrown toe-nails or varicose veins, and have for their prevention the treatment of these conditions

Club-foot (Talipes Equinovarus).—The tendency of this condition, if not properly treated, is to grow worse. Spontaneous cure is not to be expected. Treatment easily cures the condition in children; and in adults, the oldest case can be much improved, although a perfect restoration of function cannot be expected. It is a social sin for an adult to be allowed to go about in this era with club-foot. In infancy the bones are still nearly normal in shape; later, as a result of the distorted position, the ligaments and the bones become permanently changed, and treatment must be entirely different.

In the child, treatment should place the foot in an overcorrected position and keep it there until the development of the parts holds it corrected. The correction should be made as early as possible. In congenital equinovarus, treatment begun when the child is but a few weeks old finds the tissues most yielding and unchanged.

Manipulation is the first step in treatment. The infant's foot should be grasped with one hand while the other hand holds the leg. The foot is then flexed dorsally, the toes being made to approach the front of the leg, and at the same time everted, the sole being turned outward. The grasp should be firm and the movements carried as far as possible without causing the child pain. The foot should be held in this position for a few minutes, and then the manipulation repeated several times. This should be done 2 or 3 times daily, at first by the surgeon and then by an intelligent nurse or parent. This treatment can be instituted as early as the second or third week of the age of the child. The object of this manipulation is to prevent the deformity from growing worse, to prepare the foot for later fixation, and in mild cases to demonstrate beyond question that the disease is equinovarus. It can not be expected to effect a cure.

Fixation of the foot in overcorrected position must be resorted to as the curative measure in these cases. This is best done by plaster-of-Paris bandage or by some form of splint. Care must be taken to avoid undue pressure at any point or irritation of the skin (see Splints, Vol. I, page 477).

Correction with plaster-of-Paris is highly efficacious. The skin should be clean. Some zinc oxid powder should be applied. Little strips of gauze should be placed between the toes. Over the foot and leg should be smoothly drawn a seamless cotton stocking. The top of the stocking is rolled down and back as a cuff, so as to make a triple thickness just above the knee. The object of this is to introduce an extra padding under the upper edge of the plaster to prevent irritation.

If the surgeon has not skill in the application of plaster bandages, cotton wadding, cut in the form of bandages about 5 cm. (2 inches) wide, should be applied to the parts under the plaster. Plaster bandages of the same width are used. A collar of plaster bandage should first be applied around the foot just above the toes. This is held until it hardens somewhat flattened. With this as a purchase the bandage is continued, passing in such a direction as to evert the foot.

The foot is then dorsally flexed, everted and abducted as far as possible without causing pain. The stocking is smoothed, and the plaster bandage is continued. The first half roll of bandage should extend from the bases of the toes to the ankle and involve only the foot. It should not pass so high as to prevent flexion of the ankle. In applying the bandage the turns should be made in the direction of the force that is required to hold the foot corrected. The layers should be rubbed together as the bandage is applied, and the foot kept in correction. But a light bandage is needed.

As the foot is then held in corrected position the bandage is continued up

over the leg and lower third of the thigh. The knee is fixed in moderate flexion. About three bandages are required. To hold the foot in dorsal flexion, eversion and abduction, a few turns of the bandage should be carried under the sole and longitudinally up and down the leg, passing above the knee. These longitudinal folds are fixed by a few circular turns around the leg.

The bandage is removed at the end of a week, the leg and foot are bathed and gently rubbed and a similar dressing at once applied. The health of the skin is important, and if there is any irritated area, it should be well protected with powder. At the second dressing further correction can be made than at the first. The operation is repeated weekly, with a weekly gain in correction. If the plaster-of-Paris case does not hold the foot as desired, a strip of adhesive plaster may be carried partly around the foot and then up the leg, and the case applied over this. No edge of the plaster should make any greater pressure than another. Some surgeons change the dressing and make further correction with intervals of three to five days. This is entirely commendable.

After two to six weeks of such treatment, in the infant, it will be found that sufficient overcorrection has been secured. The sole of the foot,

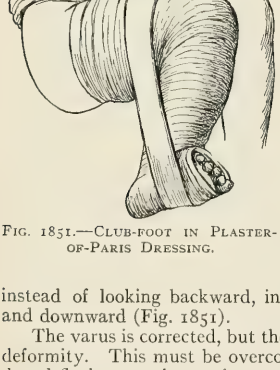


FIG. 1851.—CLUB-FOOT IN PLASTER-OF-PARIS DRESSING.

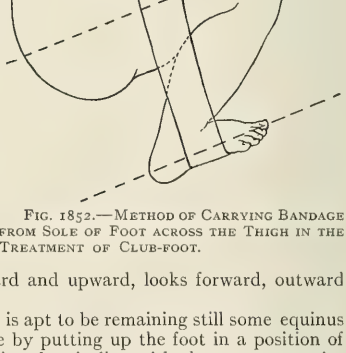


FIG. 1852.—METHOD OF CARRYING BANDAGE FROM SOLE OF FOOT ACROSS THE THIGH IN THE TREATMENT OF CLUB-FOOT.

instead of looking backward, inward and upward, looks forward, outward and downward (Fig. 1851).

The varus is corrected, but there is apt to be remaining still some equinus deformity. This must be overcome by putting up the foot in a position of dorsal flexion, not in a valgus position, but in line with the anteroposterior plane of the leg. The object of this is to lower the heel. This correction of the equinus is more difficult and requires more time and patience than the correction of the varus. Tenotomy of the tendo Achillis is indicated after about the third month in resistant cases, with extreme equinus, in which correction of the equinus without tenotomy would cause flattening of the arch of the foot. Tenotomy is also advisable in children over nine months of age in whom it is desirable to hasten the correction. Now the dressing need not be changed oftener than every two or four weeks unless soiled. Three or four months are usually required to secure the necessary degree of overcorrection.

Fixation, in corrected position, if applied to a child not over six weeks of age may be depended upon to cure most cases of club-foot without operation. A. Ehrenfried proceeded as follows in the case of infants: The corrective bandage is reapplied every two weeks. The foot, having been mobilized by manipulation, the limb from the toes to the pelvis is covered with sheet cotton. This should be applied snugly as a bandage. For an infant, three 5-cm. (2-inch) rollers of plaster-of-Paris are used. The first roller makes a collar around the foot. It should not cover the ends of the toes or cramp them, but should lie firmly against the great toe. The rest of the bandage should wait until this is hard.

The second roll is applied with the knee and ankle flexed. It passes under the foot and over the front of the thigh in such a manner as to hold the knee flexed, and the foot in dorsal flexion and outward rotation (Fig. 1852). A few last turns of this bandage then pass around the leg to hold the bandage to the calf. The third roll then covers the ankle and knee. The foot should be held abducted while the plaster dries.

Every two weeks the bandage should be removed, the deformity corrected, the limb massaged and another bandage applied.

After *overcorrection* has been secured, the subsequent dressings should hold the foot in a position of calcaneovalgus—the opposite of equinovarus. Failure in this treatment may be due to improperly applied plaster. If the bandage makes ridges, or is too tight, or too loose, it will not be effective. *Overcorrection* is most important. It should be something more than slight overcorrection; it should be extreme. It is possible, of course, to secure this forcibly at one sitting. When I was a student, working with Lorenz in Vienna in 1892, it was the practice to anesthetize the child, and forcibly overcorrect the deformity, stretching the ligaments by kneading the foot over a hard sand-bag. I have long since become convinced that this treatment should be reserved for later cases and that a better result is secured by gentler measures. Rapid correction should be employed only in older patients, and in infants who for some good reason cannot be brought repeatedly to the surgeon. Tendency to inward rotation of the bones of the leg should be treated by twisting them outward at each sitting. Each case is peculiar, and to secure success the surgeon must give close attention to all of the details. Each element of deformity must be considered separately. They are the varus, the equinus, the inward rotation of the tibia and fibula, and the elevation of the arch of the foot. When each of these has been overcorrected the next step in treatment is to be undertaken.

The *stage of retention* is that in which the parts are held in overcorrection while growth and development make permanent the change. Plaster-of Paris may be used in this stage also. If there is rotation of the leg, this can be held corrected by carrying the plaster above the knee, and fixing the knee in a slightly flexed position—flexed only enough to prevent rotation of the plaster case. If rotation is not a factor the plaster need not be carried above the knee. The plaster case during this stage may be left on for from two to eight weeks. It should be changed if soiled. After two months, a short case, ending below the knee may be applied. After this when overcorrection is found to be permanent, a light brace or a removable cast may be applied to hold the parts until the child is old enough to walk. Massage of the foot and leg should then be practised daily.

It will be noted after correction has been secured and before the child begins to walk that when support is removed the foot falls back into equinovalgus. Instead of the splints or braces to prevent this, adhesive plaster may be employed. A simple strip is placed around the foot, just

back of the toes, carried up from the outer side of the foot and made fast to the leg below the knee (Fig. 1853).

The *walking stage* should be met by securing correction as soon as possible so that the child may be on the feet. If the child is old enough to walk while treatment is in progress, it should be allowed on the feet as soon as overcorrection is secured. As soon as a plaster cast is worn out another

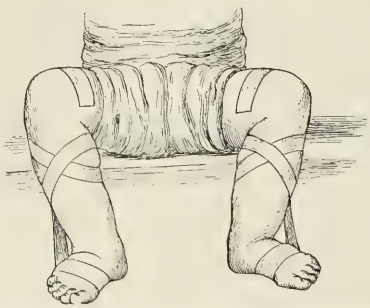


FIG. 1853.—CONTROL OF CORRECTED CLUB-FOOT BY MEANS OF ADHESIVE PLASTER STRIPS.

should be applied. Overcorrection having been secured before the walking stage the child should be allowed to walk as soon as it is ready. The foot should be watched, and any tendency to recurrence met by correction with renewal of the plaster-of-Paris. If correct on remains satisfactory the child should wear simple soft shoes. Nothing is better than moccasins.

Club-foot splints, other than plaster-of-Paris, are employed by some surgeons. The splint devised by A. Judson for use before the walking period, has found much favor. It consists of a narrow strip of sheet brass or iron, to each end of which is riveted a curved disk. A third disk or shield is used separately (Fig. 1854). The shields are lined with gauze padding. Several sizes are employed. The strips may be 9 mm. (⅜ inch), 13 mm. (½ inch), and 16 mm. (⅝ inch) in width. The disks should be about 3.2 cm. (1¼ inches) wide, and rounded at the edges. The brace is held with three strips of adhesive plaster (Fig. 1855). At each application the brace is changed in its curve to give a little more correction. It is reapplied every few days. Overcorrection is finally secured (Fig. 1856). As the foot grows a longer brace is used. As the varus is corrected, the splint is lengthened and moved posterior to the malleolus so as to operate more and more on the equinus.

FIG. 1854.—PLIABLE METALLIC SPLINT FOR TREATMENT OF CLUB-FOOT.

In some cases the foot may be held in extreme dorsal flexion, to overcome the equinus, by means of a simple *adhesive strip*, carried obliquely about the leg and across the ball of the foot. This should be done in such a way that the edge of the strip does not make undue pressure (Fig. 1857).

Comment.—The most potent factor for the cure of congenital club-foot, after overcorrection of the deformity has been accomplished, is the influence of weight-bearing upon the foot by means of walking. This factor does not come into play until the child is ten or twelve months of age. Over-

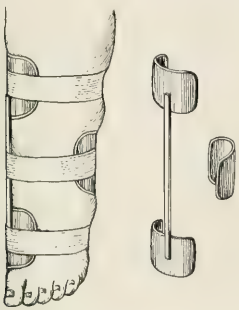


FIG. 1855.—PLIABLE METALLIC SPLINT IN ACTION.

Pads of gauze should be placed between the apparatus and the skin at all points of pressure.

FIG. 1856.—OVERCORRECTION OF CLUB-FOOT SECURED BY PLIABLE METALLIC SPLINT.

correction need not be completed until this period is reached. The case in which club-foot is discovered and treatment begun while the child is but a few weeks old has nearly a year in which to be prepared for the steps which have the greatest curative value. While there is an advantage in correcting the deformity early, the surgeon is entirely justified, if he so elect, in deferring treatment until such a time when the completion of overcorrection will be attained just before the child is ready to walk. When the latter policy is pursued the time before plaster fixation is employed should be given to manipulative correction and massage.

Tenotomy should be reserved for the last step after the valgus and exaggerated arch have been corrected.

During the stage of retention it may be found that the foot remains in an overcorrected position without any splint. In such an event the splint may be dispensed with, the foot being watched for recurrence.

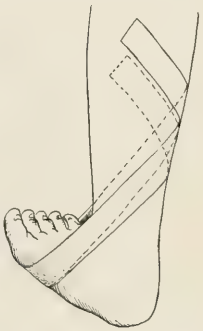


FIG. 1857.—EQUINUS DEFORMITY OVERCORRECTED BY ADHESIVE PLASTER.

When the walking period is entered upon, if there is still a tendency to recurrence, the child should wear a splint or plaster case while walking. It may be necessary to wear such a splint for a year or more. Often such a splint need only be worn at night. The necessity for watchful attention on the part of the surgeon is imperative. Recurrence may be expected if the surgeon makes the primary corrections and then dismisses the case into the hands of the parents.

As a general rule it may be said that correction done about the fourth week may be held by adhesive plaster applied to the skin. At the end of the third month plaster-of-Paris dressing is recommended. If there is inward rotation of the foot the plaster should extend well above the knee otherwise it will not control this important deformity. If varus or equinus exist at the end of the eighth month forcible correction under general anesthesia usually is indicated.

The treatment of later cases, presented for treatment just before or during the walking period, must be more active than that of younger infants. Here, in the case of children, forcible correction, carried to overcorrection, under a general anesthetic is the operation of choice. A plaster-of-Paris case should be applied and the child allowed to walk after a few days when the traumatic reaction incident to the operation has subsided. Tenotomy of the Achilles tendon is usually necessary.

Forcible manual correction was developed most effectively in the hands of Hoffa and Lorenz. It is applicable to all cases but usually need not be employed in children under eight or ten months of age. I have seen Lorenz successfully employ it in a man twenty-one years of age. This treatment is best employed from the second to the tenth year of age. It is usually best to operate on only one foot at a time. The second foot may be operated upon a week or so later.

After anesthetizing the patient the surgeon grasps the foot with both hands, one holding the forefoot the other the heel and ankle, and applies force in a direction to unbend the abnormal curve at the mediotarsal joint. The force is applied and relaxed, applied and relaxed, each effort slightly increasing the force. The object is to stretch and draw apart the interlacing fibers of the soft tissues—ligaments, fascia, tendons, and connective tissue.

In older cases more force than can be secured by the grasp of the two hands is necessary. A hard sand-bag, about 7.5 cm. (3 inches) in diameter, or a well-padded prism-shaped block of wood may be used. This is placed on the table under the convex side of the foot, and the surgeon, grasping the two ends of the curved foot makes pressure by the weight of his body (Fig. 1858). The force at first should be light, and then gradually increased. If still more force is required the surgeon may keep his arms straight, and through them throw much of the weight of his body upon the two poles of the foot. Much of the success of Lorenz in this operation was because he was over 6 feet tall and weighed around 200 pounds—repeating while he operated the mystic words, "Bei der Orthopedie hat man zu wenig auf der Elasticitat der Weichteile gerechnet."

Under this steady kneading of the foot, the structures which hold it bend and are felt to give way. Its elastic recoil back to the deformed position is lost and it becomes limp, and finally can be held in a position of overcorrection with the force of two fingers. Having overcorrected the curve in the foot, the valgus is next taken in hand. The leg is held by the left hand, grasping it at the ankle, and the right hand grasps the foot and rotates it outward. The foot is forcibly twisted outward and upward. The force is repeatedly applied with increasing effort. The soft structures yield until the sole, faces outward and downward, and the foot can be held in this position by the pressure of a finger. The equinus and cavus are next corrected by forcing the dorsum of the foot toward the front of the leg—dorsal flexion. This stretches the plantar fascia, the tendo Achillis, and their contiguous structures.

Extreme correction and restoration of the displaced astragalus are then secured by subcutaneous division of the tendo Achillis and continuation

of dorsal flexion. After the tenotomy the heel is grasped and pressed downward while the forefoot is pressed upward until the dorsum of the foot is brought almost in contact with the front of the leg. Pains should be taken to see that the os calcis is everted along with the rest of the foot. If correction can be made without division of the tendon it is highly desirable.

This operation leaves the foot quite relaxed. It should be pink and warm. The skin should not be broken except by the tenotomy operation. The operation consumes thirty or forty minutes and represents arduous labor for the surgeon. It is always to be preferred to a cutting operation because it changes all of the abnormal relations and puts the bones in new position. The whole foot participates in the correction.

The application of the dressing is important. The foot should be held by a skilled assistant in a position of overcorrection of all three of the main

FIG. 1858.—FORCIBLE CORRECTION OF VARUS DEFORMITY BY STRETCHING THE SOFT PARTS.

deformities. Gauze strips are placed between the toes. A pad of gauze is placed on the dorsum of the foot, another on the ball of the foot, and another covering the heel. These are held in position by a flannel bandage. A layer of cotton wadding, applied in the form of a bandage, is next used; this extends from the toes to the groin. Over this is applied a flannel bandage to give an even surface and hold the cotton in place. The plaster-of-Paris bandage is then applied from the toes to the groin. The toes should be covered by the bandage to prevent swelling, but their tips should be visible. An extra thickness of bandage should be placed beneath the foot.

Overcorrection should be maintained by the hands of the surgeon or assistant until the plaster is hard enough to hold it. The toes should be left exposed. They should be pink, and show active circulation. If the toes are cyanotic, an elliptic piece should be cut out of the plaster at the anterior flexure of the ankle-joint, to relieve the pressure on the dorsal vessels. After two or three days, when the traumatic reaction has subsided,

the child should be encouraged to walk about on the plaster-covered feet (Figs. 1859 and 1860).

Usually there is not the pain and swelling that might be expected. The child walks sometimes on the following day—usually within a week after the operation. What pain there is is apt to be the result of an improperly applied bandage, and it should be relieved by cutting out the plaster wherever there is a painful place. If much pain is present there should be no hesitation in removing the whole dressing and putting on another.

In the *after-treatment* it is important that the use of the foot be encouraged. The weight of the body helps to place the structures in position and influence their growth and form. An ideal practice is to incorporate a wedge of cork or wood in the plaster at the sole so that the weight is borne not only on the inner border of the foot but is evenly transmitted to the whole plantar

FIG. 1859.—UNTREATED CLUB-FOOT.

FIG. 1860.—CLUB-FOOT AFTER FORCIBLE CORRECTION.

Same case as shown in the preceding illustration.

surface. A slipper, an overshoe, or a canvas shoe may be worn on the foot for walking. If the first dressing is comfortable it is left on for three or four weeks. It will be found to be loose by the end of that time. When it is removed the foot will still be found limp, overcorrected and slightly discolored. There should be no pressure sores. The foot and leg should be washed and dried and again put up in a position of overcorrection. This time not so much cotton under the plaster is necessary. A seamless stocking may be drawn on and the plaster smoothly applied upon this. If there is no rotation of the leg—turning in of the toes—the dressing need not be carried above the knee. This second dressing may remain on for one or two months or longer. The child should be encouraged to walk.

The treatment with plaster-of-Paris, may continue about four to six months. Then position of the foot should be controlled by a simple shoe, having a brace to hold the foot in correction, if necessary. Often nothing more than a wedge on the outer side of the sole of the shoe will be required.

If a brace is used it should be very simple (Fig. 1861) and not extend above the knee. Massage of the foot and ankle and passive motion should be practised at least twice daily. The passive motion should carry the foot to a position of overcorrection of all of the positions, and the patient should be encouraged to hold these positions with the muscles of the leg.

Comment.—In older cases the astragalus is displaced downward, forward and inward, and the space between the two malleoli is too narrow to receive it even after tenotomy and extreme dorsal flexion. In such cases it may be necessary to divide the posterior ligament of the ankle at the time the tenotomy is done, and then make an incision in front of the joint, divide the ligaments with a chisel and cause separation of the *lower tibiofibular joint.*

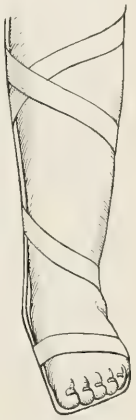


FIG. 1861.—CLUB-FOOT BRACE OF MALLEABLE METAL AT CONCLUSION OF CORRECTION.

The foot and leg should be padded with gauze. The brace is best held in place with adhesive plaster. The gauze padding is not shown in the picture.

Besides division of the tendo Achillis *division of the plantar fascia* is necessary if it can not be stretched. The tenotome is inserted at one or the other sides of the plantar band and subcutaneous division made in its middle. The tendons of the *tibialis posticus* and *tibialis anticus* sometimes require division.

To facilitate dorsal flexion and loosen the astragalus a strong band may be thrown around the foot and used for downward traction while the forefoot is pressed upward (Fig. 1862).

In very resistant cases an instrument may be used to facilitate correction. For this purpose the wrench devised by Thomas may be employed. The jaws of the wrench should be well padded and then screwed down upon the foot so that they will not slip and cause abrasions.

Open operation for congenital club-foot is employed only in cases of long standing, with resistant contractures and with changes in the shape and positions of the bones of the foot. No case is too old for operation. It is to be resorted to only in the aggravated types of club-foot. It does not offer perfect functional results, but it is capable of giving a very serviceable foot. The most satisfactory operations are those in which bone-grafting is employed.

Bone-grafting in the treatment of club-foot introduces an entirely different principle. For treating relapsed club-foot of the long slender type, with moderate adduction of the forefoot and pronounced varus, but without much hypertrophy of the cuboid bone, the surgeon proceeds as follows:

The foot and leg being prepared, the blood having been excluded, and the tourniquet fixed above the knee, the tendo Achillis and plantaris tendon are divided and the foot forcibly flexed upon the leg. A U-incision is made through the skin on the inner and upper aspect of the foot. The convexity should be forward, the base of the flap posteriorly. The upper arm should begin in front of the middle of the ankle-joint, pass forward on the dorsum of the foot nearly to the tarsometatarsal joint, curve inward across the base of the first metatarsal bone, and back to a point below and in front of the inner malleolus. This skin flap is turned back, exposing the scaphoid bone. The bone is then split transversely with a thin osteotome into an anterior and posterior half (Fig. 1863).

The incurvature of the foot is then forcibly corrected. This widens the

gap in the scaphoid. Any resistance of the soft tissues is overcome by forcibly stretching, by division through the wound or by subcutaneous division of fascia.

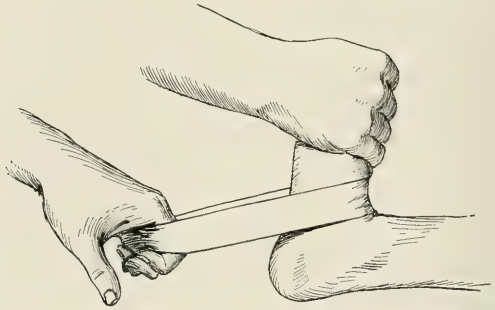


FIG. 1862.—TRACTION BAND USED TO PULL DOWN ASTRAGALUS IN FORCIBLE CORRECTION OF CLUB-FOOT.

The width of the gap in the bone is then measured with calipers. The inner surface of the tibia is exposed by a curved incision at the junction of

FIG. 1863.—BONE-GRAFT INLAY TREATMENT FOR CLUB-FOOT.

The scaphoid is exposed and split to receive the inlay. Heavy line shows site of osteotomy.

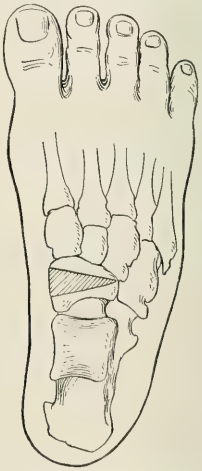


FIG. 1864.—BONE-GRAFT INLAY PLACED IN SCAPHOID BONE TO CORRECT CLUB-FOOT.

the middle and lower thirds or middle and upper thirds. A flap is turned back in such a manner that the incision does not lie on the bone wound. The

crest is freed from muscular attachments and a wedge of bone of the desired size is marked by the scalpel cutting through the periosteum. For cutting the wedge the motor saw is the best instrument. The base of the wedge is at the crest, and the apex is toward the medullary canal. It is best to drill a hole through the wedge before removing it. This hole serves for a retaining suture.

This wedge should be so nicely measured and cut that it fits directly into the split scaphoid (Fig. 1864). It should be so tight that return of the varus deformity is prevented. The edges of the scaphoid fragments are drilled, and a kangaroo tendon passed through with a short needle and tied to hold the graft. Or a bone pin may be used. The foot should remain in good position when the assistant releases it.

If the deformity has been great the skin flap which has been turned back will not cover the wound, but it will cover the scaphoid, and the rest of the wound may be left to granulate. The wound is then dressed.

A few layers of smooth gauze should be placed between the toes to absorb excretion. Cotton should not be used for this purpose. The foot and leg above the knee should be covered with tricot or a cotton stocking and a layer of sheet cotton. Plaster-of-Paris bandage is applied over all as the foot is held in a slightly overcorrected position. The knee should be flexed nearly to a right angle. The plaster should extend as far as the middle third of the thigh.

If the skin flap was adequate to close the wound and no surface was left to granulate, the wound need not be disturbed till the end of four weeks. By that time the plaster above the knee should be removed to permit motion of the knee-joint, and the wound may be uncovered and dressed. The plaster splint, holding the foot in correction, should remain on for one or two months longer. At the end of two or three months after the operation, dressings may be dispensed with, and massage instituted.

If correction is not altogether satisfactory the simple sling apparatus, consisting of adhesive plaster passed across the forefoot and on the outer side of the leg may be used. This may be modified by substituting flannel bandage or introducing elastic webbing as may be indicated. A spring apparatus which may be worn with the shoe is made for this purpose.

For treating the cases of relapsing club-foot in which the foot is short and firm, the varus extreme, and the cuboid bone so hypertrophied as to render forcible correction impossible and simple wedging of the scaphoid inadequate, F. H. Albee applies a bone wedge in the scaphoid, as described above, but takes the wedge from the hypertrophied cuboid instead of from the tibia.

For taking the wedge from the cuboid, an incision is made with its convexity upward, curving about the cuboid on the outer side of the foot. The size of the wedge desired is measured with calipers. It should be fully adequate to make the correction. The wedge should be cut with the motor saw at its beginning. This cannot be done with the whole thickness. The rest of the division may be made with a thin chisel. Before completing the resection the wedge should be drilled for the suture.

The split of the scaphoid and the stretching and division of the soft tissues on the inner side of the foot having been accomplished, the wedge of cuboid is transferred at once to the scaphoid. The division of the scaphoid and cuboid bones means that the skeleton of the foot is divided completely across. What is removed from the outer side is placed in the inner end of the bone incision. This not only corrects adduction but the varus also. The cuboscaphoid ligament is the pivot about which the rotation

takes place. As this operation is performed in the older and more intractable cases fixation in plaster-of-Paris should be continued for two or three months.

These operations are infinitely superior to the old operations which remove tissue, as they actually lengthen the already shortened foot. No joints are destroyed by the operation and consequently the flexibility of the foot is not damaged. The severest and oldest types of club-foot are amenable to this treatment.

Acquired club-foot (paralytic equinovarus) is treated by the same principle. This condition is usually due to anterior poliomyelitis, and the case should have received the benefit of treatment of the nerves, muscles and tendons.

The operation proceeds the same as for congenital club-foot until the astragaloscaphoid joint is exposed. The joint is opened and the articulating surfaces of the astragalus and scaphoid are removed with a narrow chisel and mallet. The deformity is then forcibly overcorrected, resisting soft structures being divided. The overcorrection produces a wedge-shaped gap between the bones.

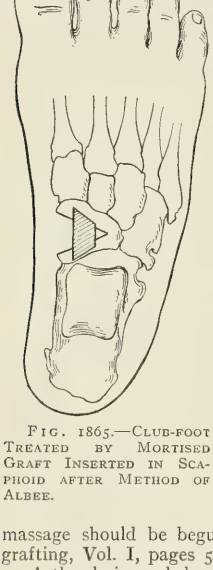


Fig. 1865.—Club-foot Treated by Mortised Graft Inserted in Scaphoid after Method of Albee.

To correct the dropping of the outer side of the foot, due to paralysis of the peronei muscles, the tendons of these muscles may be converted into ligaments. This is done by carrying a curved incision below the outer malleolus. A flap of bone and periosseous tissue is cut from the malleolus and turned back. The peroneal tendons are liberated from their sheaths and placed under this flap. After forcing the foot into a position of pronation, the peroneal tendons are sewed to the tissues behind the flap. They are thus converted into external ligaments to hold the foot in pronation.

The gap between the astragalus and scaphoid is then measured, and the necessary wedge cut from the tibia. The bones are drilled, or in the case of young children a needle will pass through the tarsal bones without drilling, and the graft fixed in place with kangaroo tendon. R. E. Soule modified this technic of Albee in such a manner that the wedge is mortised between the bones and held from inward displacement by a lip on either bone (Fig. 1865).

The foot and leg are put up in plaster-of-Paris. As soon as the wounds are healed and the bone consolidated, which requires about six weeks, massage should be begun (for the technic of these operations, see Bone-grafting, Vol. I, pages 509 and 772).

Arthrodesis and bone-fixing operations should not supersede tendon transference and grafting. The bone operations should be considered as adjunct measures.

The *destructive open operation*, which was used before the introduction of constructive bone-grafting, is carried out as follows: The tendo Achillis and posterior ligaments of the ankle are divided subcutaneously. Dorsal flexion is carried as far as possible with the aid of manual or instrumental force. An incision is then made from a point in front of the internal malleolus downward and forward to the base of the first metatarsal bone on the plantar side of the foot. The skin is dissected back, retracted, and the fol-

lowing structures divided in the order named; tibialis posticus, tibialis anticus (if it offer resistance), abductor hallucis, plantar fascia, flexor brevis digitorum, flexor longus digitorum, deltoid ligament, and calcaneonavicular ligament. This means all of the soft structures resisting correction. These tissues are divided as correction is made and the structures are found to resist. In aggravated cases in adults, it is not necessary to identify the structures; everything on the inner side of the foot, including blood-vessels and nerves, is divided.

Force is then applied to correct the varus. In some cases, even then, correction cannot be made until *osteotomy* of the neck of the *astragalus* is performed or a wedge-shaped section is removed from the os calcis. The tendo Achillis and the posterior ligament of the ankle are then divided subcutaneously, and the equinus corrected. The gaping wound is left open, and is covered with rubber protective and the foot dressed in an overcorrected position with the lower end of the tibia and fibula rotated outward. Plaster-of-Paris should extend above the knee. The dressing need not be disturbed for four or five weeks if an aseptic operation has been done.

If cuneiform *osteotomy of the os calcis* is done, the apex of the wedge should meet the linear osteotomy of the astragalus. If osteotomy of the astragalus and os calcis do not suffice then *removal* of the *cuboid* and *scaphoid* is done. Correction can usually be made after division of the soft parts. *Excision* of a portion of the *cuboid* alone is sometimes done.

Inward rotation of the tibia and fibula—toeing in—in the young can be treated with a brace to the pelvis; but in the adult or older child it is associated with bony deformity which is not to be corrected by braces. *Osteotomy of the tibia* at its lower third is indicated. This permits outward rotation. The foot and leg are fixed in plaster-of-Paris after the operation.

In some cases *removal of* the displaced *astragalus* may be advisable. The bone is easily reached by an incision passing downward and forward from the external malleolus between the tendons of the peroneus brevis and tertius. If astragalectomy does not permit correction, cuneiform osteotomy is the next step.

These destructive procedures are rarely indicated in the hands of a surgeon capable of performing the constructive bone-grafting operations.

The operation of *cuneiform osteotomy*, by which a wedge of bones is removed from the outer side of the foot, was once much in favor in aggravated cases. The astragalus is usually first removed. Then through an incision on the outer side of the foot, parallel with the tendons, a wedge-shaped section is removed, involving the os calcis, cuboid, and scaphoid bones. The external malleolus may need to be removed.

These osteotomies are done only in old and aggravated cases. Most cases in which they have been applied could have been cured with a better result by forcible manipulation or bone-grafting. All of these mutilating operations make it impossible to restore the foot to normal. They should be resorted to only after the more conservative measures have failed.

The *after-treatment* of operative cases is conducted upon the same principles as that of cases treated by manipulation. The first dressing should be left undisturbed for a month if possible. If need be, in the interest of cleanliness, an opening may be cut in the plaster and the covering of the wound changed at the end of a week. The plaster dressings should be continued for at least six months, being renewed as often as they become soft or soiled. Following the plaster splint a shoe with a brace should be worn.

If there has been inward rotation, the brace should be attached to a pelvic

band. The outer side of the sole and heel of the shoe should be about 6 mm. (¼ inch) thicker than the inner side to tilt the foot outward.

Congenital Talipes Varus.—This form of club-foot without the equinus deformity is treated the same as equinovarus excepting that no operation for dorsal flexion is necessary.

Congenital Talipes Equinus.—Manipulation, tenotomy, and retention in an overcorrected position are required.

Congenital Talipes Calcaneus.—This rare condition requires that the foot be forced down into an equinus position several times a day, and the muscles of the calf stimulated by electricity and massage. If there is backward bowing of the tibia it should be corrected. Tenotomy of anterior tendons is rarely necessary.

Congenital Talipes Valgus.—Massage and corrective manipulation should be applied. When the child walks, the inner side of the sole and heel of the shoe should be raised by a wedge, making them about 6 mm. (¼ inch) thicker than the outer edge. In older cases, not cured by these measures, osteotomy of the tibia and fibula, to produce a slight bow-leg may be of service.

In old intractable cases *arthrodesis* of the astragalonavicular joint may be combined with tendon transplantation. An incision is made along the inner side of the extensor longus hallucis opposite the astragalonavicular joint. The cartilage is removed from the bones. The tendon of the tibialis is divided obliquely and shortened. The tendon of the proprius hallucis is divided and attached to the insertion of the tibialis anticus while the foot is held in corrected position. The ligaments are sutured in shortened position, the wound closed and the foot put up in plaster in extreme inversion and slight dorsal flexion.

Pes Cavus.—This condition, commonly associated with equinovarus, is the first to be treated in ordinary club-foot (see Equinovarus). It is treated by manipulation and forcible correction. When this fails, subcutaneous division of the plantar fascia is called for. A steel plate in the sole of the shoe and an elastic band over the dorsum of the foot helps to lower the arch. Overcorrection should not be carried too far as a high arch is better than a flatfoot (see Hollow Foot, page 489).

Claw-foot.—This condition is like pes cavus, but presents not only contracture of the plantar structures but also shortening of the extensor tendons which causes hyperextension of the first metatarsal bones. Varus is not necessarily present. If there is no remediable nervous cause, and the condition is so aggravated that massage and hygienic shoes fail to cure it, operation will give relief. Tenotomy or lengthening of the shortened extensor tendons is the first step. This should be done deliberately and in as many stages as seems best. Usually all of the shortened tendons may be operated upon at one sitting through a transverse incision or two longitudinal incisions on the dorsum of the foot. At a later operation the contracted plantar structures should be divided as for pes cavus.

Equinovalgus, Calcaneovalgus, Calcaneovarus, Equinocavus, and Valgocavus.—These are all combinations and modifications of the above, and are to be treated by the methods already described.

Acquired Paralytic Talipes.—The treatment of the nerve disease is the important thing in these cases (see Nerves and Muscles). The health of the muscles should be kept in as good a condition as possible by massage. In the absence of operation on nerves or tendons a shoe should be worn which corrects the deformity and permits the foot to bear the weight of the body. Whether a cure of the paralysis is to be expected or not. The restrictions to the normal range of motions should be removed by stretching or subcu-

taneous division of resisting parts. Braces in addition to the shoe are often necessary. Whatever the deformity is it should be corrected, and the foot walked upon. This is most important. The parts should be kept in normal position and used (see Bone-grafting for Acquired Talipes, page 478).

Tendon transplantation is useful in many of these cases and may be done alone or combined with other operations.

A strip of the tendon of the peroneus longus is split off and attached to the tibialis anticus muscle. This gives virtually a second insertion of the tibialis. This may be done by carrying the slip of peroneus tendon obliquely across the dorsum of the foot, opening the sheath of the tibialis anticus and making the connection; or the whole tendon of the longus may be divided, brought out through a puncture back of the base of the fifth metatarsal bone, carrying it through a tunnel under the dorsal fascia of the foot, and sewing it to the anticus above the transverse ligament (see Operations on Tendons for Infantile Paralysis, Vol. I, page 805).

Paralytic toe-drop may be corrected by a series of operations. First, the tendo Achillis is elongated to permit placing the foot at a right angle. An incision 10 or 12 cm. (4 or more inches) long, is then made to expose the anterior tendons. This incision is placed on the front of the leg just external to the crest of the tibia and ends below just above the ankle-joint. The anterior tendons are then divided at the upper part of the incision where they join their muscles. At the middle of the incision, the tibia is bared. The periosteum is lifted up and a hole bored through the bone big enough to receive all of the divided tendons. A tendon is passed through the hole, another is passed through in the opposite direction, and so on alternately until all of the tendons of the paralyzed anterior muscles have been passed through the bone. They are then sewed to the periosteum, which is placed over the ends, with chromicized catgut. Enough tension is made to hold the foot at a right angle; and in this position the foot is immobilized for about two weeks. This operation can be applied to any form of paralytic deformity.

The same principle may be used with the tendo Achillis and plantar flexors in talipes *calcaneus*. For *valgus*, the tibialis anticus or posticus or both may be used; and for *varus*, the peronei may be employed.

When this operation is done for toe-drop, the toes will stand out straight provided the plantar flexors also are paralyzed, but if the plantar flexors are not paralyzed, a condition of hammer-toe will develop in all of the digits. To prevent this, J. Torrance Rugh (Annals of Surg., 1914, vol. 59) proposed engrafting the tendons of the dorsal flexors into the distal ends of the metatarsal bones by lifting a flap of periosteum and placing the tendons in a groove under it.

Of course, none of these operations which sacrifice muscles should be done until exercises, massage and time have all been given a chance to restore function. After six years of paralysis, it may be assumed that the muscles are irreparably paralyzed, and these operations may be performed.

Paralytic equinus is commonly present. Division of the tendo Achillis may suffice to place the foot in normal position. If it does not, a brace with a plate in the sole of the shoe, allowing motion at the ankle and having light elastic dorsal flexion, will prevent the dropping of the toes.

In cases in which the muscles of the leg are paralyzed beyond recovery, *arthrodesis* of the ankle and mediotarsal joint may be done to fix the foot at a right angle. An incision is made on the dorsum passing between the tendons. The two joints are exposed and the cartilages of their articular surfaces removed with a knife or chisel (see Vol. I, page 738).

Paralytic calcaneus, due to paralysis of the muscles of the calf, is to be treated by the same principles as paralytic equinus. Contracted structures should be stretched or divided. A brace, similar to that used in equinus, may be employed. In younger children prolonged fixation with plaster in the equinus position is often of value.

The *operative treatment*, as carried out by R. Whitman (Annals of Surgery, Feb., 1908) in confirmed cases, especially with lateral displacement which makes the use of a brace difficult, is as follows: An incision, beginning behind and above the external malleolus, passes below the malleolus and ends at the outer side of the head of the astragalus. The tendons of the peronei muscles, the lateral ligaments of the ankle and the interosseous ligament are cut. The astragalus is removed. A thin piece is removed from the outer surface of the os calcis and cuboid bone. The calcaneonavicular ligament is partially separated from the scaphoid bone. The internal lateral ligament is divided, and the cartilage is removed from the two malleoli. By displacing the foot backward, the external malleolus is made to cover the calcaneocuboid joint, and the internal malleolus enters the depression behind the scaphoid bone. An opening is made in the tendo Achillis, through which the peronei tendons are drawn and sewed fast. The wound is closed, and the foot is fixed in a position of equinovalgus by plaster-of-Paris which should extend above the knee. After three weeks the plaster is removed and a plaster case, fixing the foot in slight equinus, with a lift under the heel, is applied to the foot and leg. Later a light brace is used instead of the plaster. In about six months the brace is dispensed with and a cork lift under the heel is used. The result of this treatment is a movable ankle joint and a support secure enough for the patient to get along without a brace. The operation gives a more satisfactory foot than does arthrodesis.

Paralytic equinovarus is treated by the same principles as above. The deformity should be corrected by manipulation. The foot should be held in an overcorrected position, supported by a brace, and its use encouraged. Massage of the muscles should be practised daily. The manipulation and operative measures employed in congenital talipes may be required. Transplantation of a half of the insertion of the tendon of the tibialis anticus from the inner to the outer side of the foot may be of use. Arthrodesis of the astragalonavicular articulation, placing the foot in slight abduction, may be combined with the tendon transplantation. For correcting the deformity and fixing the foot in position, bone-grafting as described above (page 478) has much to offer.

Paralytic valgus is treated like the congenital variety, after everything possible has been done for the nerves and muscles. Replacing the foot in overcorrected position and holding it there with plaster or a brace is important. A lift may be worn on the inner side of the sole and heel of the shoe to throw the weight to the outer side of the foot. Osteotomy of the fibula with inward bending of the lower fragment is often indicated.

Talipes Due to Disease of Bone.—In various forms of club-foot, due to fractures or disease of bones of the foot and leg, the principles of treatment are the same as for the congenital variety. *Talipes valgus* due to faulty healing of *fracture of the leg* is best treated by corrective manipulation, osteotomy of the tibia just above the ankle and immobilization of the foot and leg with the foot slightly inverted so as to cause the weight of the body to fall to the outer side of the foot.

Flat-foot (Weak-foot).—To understand the treatment of this condition one must understand that the falling of the arch (the flat-foot) is not the whole of the pathology, but that the foot is displaced outward so that the

weight of the body falls too much upon the inner side; and the foot is rotated outward so that in walking the force of the body tends to evert the foot and the weight of the body is thrown upon the inner side of the arch. The leg instead of resting on the top of the arch of the foot tends to ride off at the inner side and to cause the top of the foot to roll inward with it. This gives rise to: (1) *Pes planus* or falling of the arch, (2) *pes valgus* or abduction of the foot, or (3) *pes planovalgus* which represents depression of the arch combined with abduction.

The thesis that flat-foot if not painful needs no treatment should not be approved. A flat-foot is a disordered foot; it interferes with proper function; in children it may give no pain, but no child should be permitted to grow up with this deformity, for sooner or later when cure has become difficult pain may be expected to develop; and it is always productive of defective gait and deficient suppleness of the lower extremity.

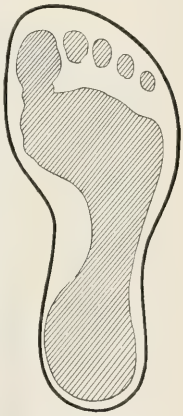


Fig. 1866.—Proper Shape of Shoe.

Preventive treatment should correct "out-toeing" or the position which many children have of turning the toes outward. Children should be taught to stand and walk with the long axis of the foot directed forward—not like a soldier but like an Indian. Knock-knees should be corrected as this condition conduces to flat-foot. The exciting cause of flat-foot is standing while in a state of fatigue. Avoidance of this cause is imperative. Shoes which squeeze and deform the foot should be avoided. That means the average shoe worn in Christendom. Defective circulation, as evidenced by varicose veins, cyanosis and congestion of the feet, is a prolific cause, and should be corrected. The first step in treatment is to remove the causes. Persons who must stand much should learn to throw the weight of the body on the outer part of the foot. Shoes should provide for ventilation.

The mistake should not be made to treat "fat-foot" for flat-foot. In the former the arch is filled with fat and areolar tissue, but the bony relations are not disturbed. Neither is it necessary to treat the common variety of flatfoot which is associated with bow-legs. This latter is a compensatory valgus and rarely gives rise to any disturbance.

Unless the causative factors are removed or active treatment instituted the tendency of flat-foot is to become aggravated until locomotion is seriously impaired. This I have substantiated by the study of several thousand cases observed in connection with the Police and Fire Departments of the City of New York.

Active treatment can do much for this condition. It is first essential that the deformity be corrected. The foot should be subjected to passive motion and corrective manipulation until it can be made to move through all of the range of the normal foot. Then it must be retained in normal position. The *shoe* should be so broad that when the weight of the body falls on the foot the natural spread of the foot is not hampered. The toes should not be restricted but should be free to straighten out and to grip the ground as a claw in walking. The heel should be low and broad, or better still, there should be no heel (Fig. 1866). A valuable help is to raise *the inner half of the sole and heel* of the shoe about 6 mm. (¼ inch) thicker than the outer

half. This is done by adding a wedge-shaped lift of leather to the inner side of the sole and heel. It helps to balance the foot by throwing the body weight further outward.

The patient should be instructed to keep the foot in a proper *attitude* both in walking and at rest. The feet should be kept parallel when walking. When at rest the legs should be rotated inward, and the muscles of the foot exercised. The patient should press the toes downward against the sole of the shoe and elevate the arch by contracting the tibialis anticus.

There are certain active *exercises* which are of great value. The muscles which adduct the sole of the foot, or rotate it inward, should be exercised. The patient should stand with the feet parallel; then contract the calf muscles and raise the body on the front of the foot as far as possible; then he

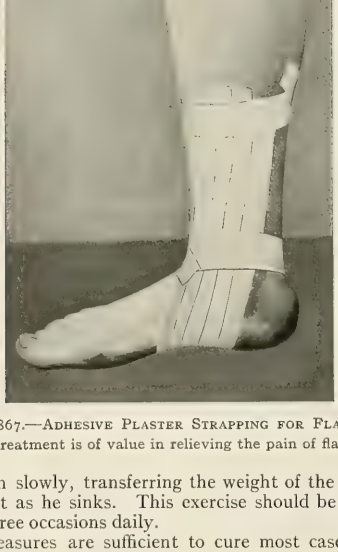


Fig. 1867.—Adhesive Plaster Strapping for Flat-foot. This treatment is of value in relieving the pain of flat-foot.

should come down slowly, transferring the weight of the body to the outer borders of the feet as he sinks. This exercise should be repeated 25 to 50 times on two or three occasions daily.

The above measures are sufficient to cure most cases of flatfoot. In addition to these exercises *massage* of the foot, with passive motion to elevate the arch, is of value but not necessary to effect a cure. Strapping with adhesive plaster to elevate the arch and give some adduction may be found useful in some cases (Fig. 1867).

In aggravated cases, in patients who cannot by their own muscular effort voluntarily lift the arch and overcome the deformity, and in children too young to coöperate in the treatment, some form of artificial support must be used to hold the foot in the corrected position. For this purpose a *plate* is constructed to be worn in the shoe. Such a plate is best made from a plaster cast taken with the foot lying on its outer side and slightly adducted. The

plate should be made of thin sheet steel—tempered, light, and covered with leather. The plate should have an arch to lift up the mediotarsal joint (Fig. 1868); it should be reflected up on the inner side of the foot to cover the

FIG. 1868.—FLAT-FOOT PLATE.
Inner side.

astragalonavicular joint; and on the outer side to cover the calcaneocuboid joint (Fig. 1869). As the foot improves, a new model should be made with a still higher arch. The foot exercises should be carried out as above directed. A plate should never be regarded as the whole of the treatment. The plate should be dispensed with inside of three to nine months. The other treatment should be continued.

In children, massage, corrective manipulations, the plate, a leg and ankle brace to correct valgus if necessary, exercises such as bicycle riding, walking on stilts, and dancing, are the main elements of treatment.

The *operative treatment* of flat-foot has much to offer. As the forward end of the os calcis is too low this may be corrected by *division of the tendo Achillis* and the posterior ligaments of the ankle, thus allowing the heel to drop downward. Shortening of the tendon of the tibialis anticus is of help in some cases (see Talipes Valgus, page 482). In cases of knock-knee, *osteotomy* to correct the deformity is often essential to a cure. Flat-foot, following fractures of the leg with faulty union, requires osteotomy and correction of the valgus. A tendency toward bow-legs is a guarantee against flat-foot in these cases.

FIG. 1869.—FLAT-FOOT PLATE.
Plantar view.

The operations which are rarely indicated are those which aim to change the bony structure. A vertical incision may be made between the tendo Achillis and the external malleolus. Through this the tendon is divided. The tuberosity of the os calcis is then cut from the body of the bone with a thin chisel and the periosteum on the opposite side divided with a knife so that the detached bone is freely movable. The

tuberosity is then displaced downward and slightly inward, thus producing a posterior limb of the arch and correcting the valgus. A hole is drilled and a bone-peg driven through the tuberosity to hold it to the body. The foot is put up in plaster-of-Paris and weight-bearing abstained from for two or three months.

Another operation removes a wedge of bone, with its base downward and inward at the point of the greatest inward convexity; this is at the head of the astragalus. Osteotomy of the tibia and fibula just above the malleoli is also done in some cases, and the bones immobilized in a position which bends them toward the bow-leg deformity with the view of throwing the weight of the body more toward the outer part of the foot.

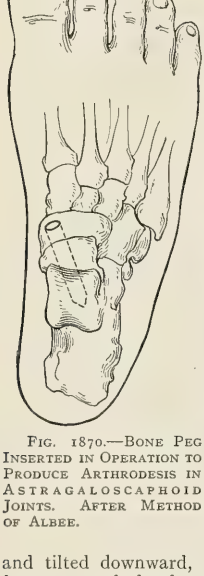


Fig. 1870.—Bone Peg Inserted in Operation to Produce Arthrodesis in Astragaloscaphoid Joints. After Method of Albee.

Arthrodesis of the astragaloscaphoid joint for flat-foot is done in cases of persistent, relapsing, painful, relaxed and pronated foot, after conservative treatment has failed. Under general anesthesia, adhesions are broken up and the joints of the foot thoroughly loosened by forcible manipulation. These movements are carried out until the arch of the foot can be restored and the foot strongly adducted. Arthrodesis of the astragaloscaphoid joint is then done through a curved incision which turns down a flap with its base at the sole. The tendon of the tibialis anticus is exposed and retracted downward. The joint is opened, and with a thin curved gauge the articular surface is removed from both bones. The convexity of the astragalus and the concavity of the scaphoid should be preserved.

As the foot is held in corrected position a hole is bored backward through the inner end of the scaphoid into the astragalus, and a bone-peg, taken from the patient's tibia, is driven into it (Fig. 1870). The wound is closed, dressed, and the foot put up in plaster-of-Paris extending above the knee. The foot should be kept thus immobilized for two months or longer. The patient should wear an arch supporter for a few months when walking is first attempted.

Rigid Flat-foot.—This extreme deformity in which the front of the os calcis is rotated inward and tilted downward, the astragalus slipped downward and inward, the front part of the foot bent outward, and the whole foot rigidly held in the deformed position by muscular spasm and inelastic locking of the parts, is entirely amenable to treatment. Under general anesthesia it will be seen that that part of the deformity due to muscular spasm corrects itself. The remaining deformity should be corrected by forcible manipulation. The foot should be forcibly and repeatedly flexed, extended, abducted, adducted, and rotated until adhesions are broken and ligaments stretched and a thorough relaxation secured. To obtain extreme flexion, division of the tendo Achillis will often be necessary. The manipulations should be made over a sand-bag or padded block as in the treatment of talipes, or the foot may be held between the knees of the surgeon. Tenotomy of the tendons of the peronei may be necessary.

When relaxation and a wide range of mobility have been secured the

foot should be strongly inverted into a position of varus. This replaces the os calcis under the astragalus and brings the scaphoid bone into position. The foot should be flexed to a right angle which is as far as flexion in the varus position can be carried. The foot is treated just as club-foot. It is put in plaster-of-Paris in overcorrected position, and the patient encouraged to walk. Bearing the weight on the outer side of the foot promotes correction. Both feet may be operated upon at one sitting.

The foot should be kept in the overcorrected position about four months. At the end of that time a plate, such as is used for flat-foot, should be made. This is best constructed after a plaster mould of the foot. The plate should be worn in a proper shoe. Massage and passive motion through all the excursions of the foot should be practised daily. Later the exercises recommended for flat-foot should be practised night and morning. After a few months' use of the plate the inner border of the sole and heel of the shoe should be raised and the plate omitted. The exercises should be continued until a cure is secured.

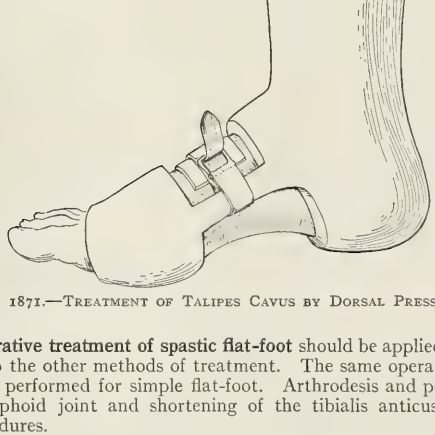


FIG. 1871.—TREATMENT OF TALIPES CAVUS BY DORSAL PRESSURE.

The **operative treatment of spastic flat-foot** should be applied in cases not amenable to the other methods of treatment. The same operations may be done as are performed for simple flat-foot. Arthrodesis and pegging of the astragaloscaphoid joint and shortening of the tibialis anticus tendon are useful procedures.

Hollow Foot (Talipes Plantaris).—That condition in which the arch of the foot is greatly exaggerated requires no treatment unless there is discomfort. Usually disability is present. Discovered in early life, the deformity may be cured by manual correction. Mild cases are cured by substituting proper shoes for those sold in the shops. In aggravated cases operation is necessary.

For *division of the plantar fascia* a long narrow knife is used. This is passed under the skin at one side of the foot, rotated and caused to divide the fascia. Resisting bands should all be divided. The knife may have to be entered in more than one place. When all plantar bands are divided, forcible dorsal flexion of the foot should be practised for the purpose of lower-

ing the arch. For this purpose the foot wrench employed in club-foot may be needed.

The exaggerated arch may be associated with tension of the extensor muscles producing hammer-toe deformity in all of the toes and obliterating the transverse anterior arch of the foot. This calls for division of the tendons of the extensor muscles, including the tibialis anticus. After dividing the resisting structures, a flat splint should be placed on the sole of the foot. A small pad should be placed under the middle of the ball of the foot to restore the transverse metatarsal arch, the toes should be straightened, and the foot should be bandaged down to the splint. The patient should walk about with this dressing. One or two months of this treatment are necessary.

A. Ritschl (Medizin. Klinik, June 13, 1915) applied a plaster case, having a dorsal and plantar fenestrum, through which a strap made pressure upon a dorsal pad (Fig. 1871) (see Pes Cavus, page 482).

Depression of the Transverse Arch of the Foot (Weakness of the Metatarsal Arch).—This condition which gives rise to *anterior metatarsalgia* (first described by T. G. Morton of Philadelphia, Am. Jour. Med. Sciences, August, 1876) is a most common cause of foot disability. In its treatment the surgeon should bear in mind that normally the distal ends of the second and third metatarsal bones are higher than the first and fifth, and that this transverse arch is necessary for the resiliency of the foot. The nerves which are caught between the bones when this arch falls can be relieved only by restoring the normal relations. The disease is to be prevented by avoiding the conventional shoes of Christendom. These shoes have a sole narrower than the foot, pinch the anterior arch, lift up the fifth and first metatarsal bones, and consequently cause a compensatory lowering of the others.

The first step in treatment is to employ suitable shoes, which do not check the lateral spread of the anterior arch when the weight of the body falls upon it. A small oval pad should be placed just behind the head of the third metatarsal bone. It should be about 1 cm. (⅓ inch) thick. It may be strapped to the foot or fixed to the sole of the shoe. This may be made of gauze or leather. If neuritis is present and the pain is severe, immobilization of the joints of the foot is necessary. This is best done with a plaster-of-Paris dressing, the anterior arch being held up in normal position while the plaster hardens. Complications such as falling of the plantar arch, hollow foot, and spastic contractures, must receive their appropriate treatment.

Morton recommended resection of the head of the offending metatarsal bone in intractable cases. An incision should be made on the dorsum of the foot over the metatarsophalangeal joint at the side of the extensor tendon. The head of the bone is exposed and removed. Rarely should a case require this treatment.

Painful Feet.—A common form of this condition follows infections in other parts of the body, such as occur in the teeth, tonsils and nose, and in grip, typhoid and other infective diseases, and requires recognition of the cause. These diseases are capable of producing an infection among the bones of the foot, which is best treated by immobilizing the foot in plaster-of-Paris, and holding the arch properly elevated. Many of these cases are due to gonorrhea and clear up when the gonorrhea is cured. Syphilis should be looked for in intractable cases.

If the immobilization is not promptly made, or if for some other reason the inflammation persists, ankylosis between the bones takes place and the so-called *static foot* results. The best treatment for this consists in hot

applications. These may be made by enveloping the foot in hot, wet compresses, hot clay, or hot sand, or, what is still better, hot dry heat. This latter may be generated in the electric baker, and should reach 95°C. or 200°C. (200°F. or 400°F.). The heat should alternate with massage.

Obliterating endarteritis, producing defective circulation and threatening or actually leading to gangrene, must be treated by the medical measures employed in that condition. Dry heat relieves the pain for a time, but gives no permanent relief. Exposure of the foot to the sunlight seems to cause permanent improvement. The internal administration of thyroid extract seems helpful.

Aside from the above there must be identified the painful foot of flat-foot, high arch, gout, and the other conditions which cause pain.

Hammer-toe.—This condition of hyperextension of the proximal phalanx and flexion of the second phalanx is caused usually by shoes which are too short or too narrow, and accordingly is prevented by wearing proper shoes. In young infants, the congenital cases may be treated by carrying adhesive strips over and under adjacent toes to correct the deformity. In young persons the deformity may be corrected by strapping down the toe to a plantar splint.

Rarely can a case be cured by division of the soft parts, but tenotomy and division of the fascia may be tried. In adults the curative operation is removal of the distal end of the first phalanx. This is done through a lateral incision. The phalanx is shortened, and extension of the joint permitted. The toe should be kept on a splint until it is healed. Amputation is not to be done for this deformity.

If there is a corn or much thickening over the joint it may be excised by an elliptical incision. Through this the middle part of the extensor tendon is divided, and the head of the first phalanx removed through the opening in the tendon.

Claw-toe is a form of hammer-toe existing in several toes. Its treatment is the same as hammer-toe.

Overlapping Toes.—This condition may be corrected in infancy by manipulation. In older patients bandaging with adhesive strips may be employed. A strip of flat lead is useful. In confirmed cases the operative division of resisting tissues or resection of a joint will be necessary.

Hallux Valgus (Bunion).—Outward deflection of the great toe is prevented by abstaining from the conventional shoes which crowd the toes. The discomfort of the condition may be relieved by wearing shoes having size enough to accommodate the foot in its normal movements. If the sole is made a little thicker on the inner side the weight of the body does not crowd the sensitive joint against the upper of the shoe. A plate may be introduced in the shoe, having a post or septum standing up between the first and second toes. Such a plate may be made of sheet metal, and the septum constructed of a fold of the metal. At night a simple straight splint may be attached to the inner side of the toe and foot and strapped on in such a way as to adduct the toe. Rarely will a patient have the patience to persist in these measures. He will either be satisfied with a comfortable shoe or will require operation.

The *operative treatment* is a partial resection of the first metatarso-phalangeal joint. It aims also to remove the projecting bone. Blood should be excluded from the foot by rubber bandage. An incision is made on the inner side of the joint, slightly curved, with its convexity upward. The center of the incision should be at the junction of the inner and dorsal surfaces so that the scar shall be the least exposed to pressure. The skin flap

should be dissected down and the capsule of the metatarsophalangeal joint and the periosteum exposed and incised in the same direction as the skin. The flap of periosteum and capsule should be dissected down from the two bones.

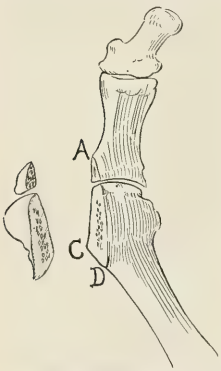


FIG. 1872.—OPERATIVE TREATMENT OF HALLUX VALGUS.

Showing division of bone. *A*, Resection of first phalanx; *AC*, plantar line of resection; *AD*, dorsal line of resection.

The exostosis on the head of the metatarsal bone should be removed subperiosteally. This is done with a thin sharp chisel or a fine circular saw. Bone forceps or other blunt instruments which crush and disorganize the bone should not be used. The plane of resection should pass obliquely outward, and should remove more of the inner side than of the outer side of the head. Under no circumstances should much of the plantar surface of the head of the bone be removed. This is necessary to preserve the anterior support of the plantar arch and the internal support of the transverse metatarsal arch. The resection passes behind the joint (Fig. 1872). The prominent remaining inner side of the head is cut off, and, if necessary, any inward projection of the phalangeal base is also removed.

The next important step of the operation consists in cutting free a flap, having its base forward, which contains the bursa lying at the inner side of the joint. This is freed by cutting out the bursa from the flap of soft tissue that was first turned down. The bursa is tucked into the joint between the bone-ends and held there by a mattress suture of chromic catgut which catches the base of the bursal flap and sews it to the periosteum on the inner side of the metatarsal bone (Fig. 1873). The external flap is then sewed in place. The wound should be closed with

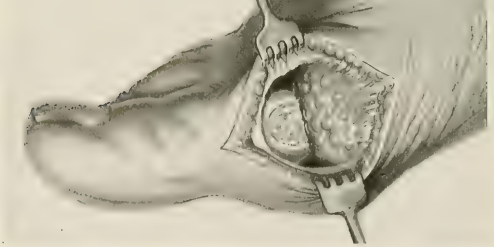


FIG. 1873.—OPERATIVE TREATMENT OF HALLUX VALGUS.
Showing flap of fascia and bursa inserted between the bones.

niceness in order that there should be the least possible scar. A gauze pad is placed between the first and second toes, and the wound dressed. The patient may be allowed to walk in two weeks.

A serious mistake is made if enough bone is removed to impair the bulk of the head of the metatarsal bone. If no bursa is present, a flap of connective tissue will answer quite as well. If there is not enough tissue a piece of free fascia may be taken from the outer side of the thigh and sewed between the bone-ends.

Approximately this operation was first described by W. J. Mayo. The bursal flap in the Mayo operation is not attached to the skin flap but is left connected with the periosteum, the superficial flap containing only skin.

In some cases the deformity seems associated with hypertrophy of bone on the inner side of the joint. In some of these cases all that is required is the removal of this hypertrophied bone. This is done by chiseling it away longitudinally, without removing the whole articular surface of either bone. The amount of bone removed from the dorsum should be more than from the plantar side. The toe is forcibly adducted into a corrected position. The capsular ligament and periosteum having been saved, they should be sewed down snugly against the raw bone surfaces, and held there after closure of the wound by the pressure of the dressing. If possible the capsule should be shortened by making a vertical fold so situated that it falls between the two bones. The wound should be closed with fine buried catgut. A pad between the first two toes serves as a splint. A smooth gauze dressing splints the whole foot. At the end of a week or ten days passive motion should be begun to prevent ankylosis. A digitated stocking or a pad between the toes should be worn to prevent recurrence.

Commonly these cases also have falling of the metatarsal or the plantar arch with outward displacement of the proximal end of the first metatarsal bone. These conditions should receive treatment before the operation for the hallux valgus is done.

Bunion (inflammation of the inner metatarsophalangeal bursa) should be treated by the measures described for bursitis (Vol. I, see page 819). Operation for hallux valgus should not be done while acute bursitis is present. Such an acute bursitis is best treated by hot applications and freedom from pressure. For chronic bursitis ichthyol ointment is of value. Suppuration of the bursa demands incision. Cure of the hallux valgus and proper shoes are the important factors.

Corns.—Skin callosities are to be prevented by properly fitting shoes. Corns are produced by unnatural pressure. Besides the measures already described see Callositas and Clavus, Vol. I, page 841. Adhesive plaster applied in the form of a bandage over the corn, and worn for six or eight weeks, causes it to soften and become exfoliated.

Ingrown Toe Nail.—This very common disorder does not always require radical surgical treatment. Proper fitting shoes should relieve the toe of pressure. Cleanliness is the next important thing. If there is much swelling, a large, hot, wet, antiseptic dressing should be applied, and kept covered with impervious protective. Alcohol and water or boracic acid solution are effective. After a day or two of this treatment, or immediately, if there is no considerable swelling, the curative measures may be adopted. Granulations are touched with pure silver nitrate or a drop of phenol. A mild astringent powder is then applied. For this purpose subgallate of bismuth, subnitrate of bismuth, tannic acid, stypticin, tannoform, dried alum or calomel may be used. The powder is applied and a thin smooth piece of fine linen or cotton cloth is tucked under the edge of the nail. This is done by lifting up the corner of the nail with forceps while with a narrow pointed instrument the cloth is placed under the corner and lateral edge

as far back as possible. The powder is carried along with the cloth. The excess of cloth is cut away. This introduces a fabric dressing between the irritating edge of the nail and the irritated soft tissues. This dressing may be left for two or three days if it remains dry. By keeping the nail and the soft tissues separated the disease is easily cured.

Recurrence may be expected if ill-fitting shoes are worn. *Operation* is not necessary unless the patient insists upon continuing to wear the conventional disease-producing shoes. For such unfortunate cases the following operation is done: A V-shaped incision is made with its apex at the root of the matrix of the nail. Within the wedge are the swollen and irritated soft tissues, about one-fourth of the nail, and its underlying matrix. The wound is partially closed with one or two sutures (Fig. 1874).

Perforating Ulcer of the Foot.—This condition is so commonly complicated with syphilis, arteriosclerosis, diabetes, peripheral neuritis, chronic alcoholism, injury of the spine, or injury of the bones of the foot that the associated factor must always be sought out and, if possible, corrected. The patient should be put to bed, the foot washed, and enveloped in a copious wet boracic acid dressing. This should be kept wet and changed daily. At each dressing the hardened epithelium around the ulcer should be removed and the cavity injected with iodin or silver solution. After about two weeks of such treatment the ulcer is seen to be surrounded by healthy skin. Along with these measures should go treatment of the constitutional disease. Stretching of the sciatic nerve has been effective in nerve cases. Good results have been secured by stretching the plantar nerve and the tibialis.

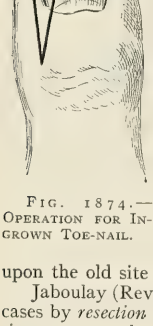


FIG. 1874.—OPERATION FOR INGROWN TOE-NAIL.

In many cases there is disease of the bone or a joint. The *x*-ray will often show it. In these the deeper disease should be exposed by incision. Necrotic bone should be removed. A diseased joint, between the bones of the foot, may be found. Necrotic cartilage should be removed. Diseased synovial membrane may be sterilized with iodin. Free drainage should be provided. After-care of the foot is important. Prolonged pressure upon the old site is apt to provoke recurrence.

Jaboulay (Rev. Med. Suisse, xxxvii, January–February, 1917) cured these cases by *resection of the nerve fiber sheath* of the femoral artery. This operation seems to have a favorable influence on trophoneurotic lesions. The operation seems to have the same good effect as in causalgia, Raynaud's disease and other painful affections associated with neuro-arterial disturbances. Under local anesthesia a periarterial sympathectomy is performed in Scarpa's triangle, the femoral artery being denuded of its sheath for a distance of 6 or 7 cm. This operation takes away the sympathetic nerve filaments. The benefit seems to be durable.

Achillobursitis (Achillodynia).—This painful affection, due to inflammation of the bursa between the tendo Achillis and the os calcis, may be relieved by rest secured by fixing the foot at right angle with plaster-of-Paris. Mild cases may be cured with rest and hot applications. Adhesive-plaster strapping, to make pressure, limit motion, and take some of the strain from the tendon, is useful in mild cases. Cases not yielding to these measures are cured by removal of the bursa. It is exposed by incision along the inner edge of the tendon. The bursa lies just in front of the tendon above its insertion. After operation the foot is kept quiet for a few days and then

motion may be resumed. Gonorrheal infection may require treatment in this, and the following condition. Suppurating bursa requires incision (see Bursitis, Vol. I, page 819).

Painful Heel.—Pain at the bottom of the heel, due to *calcaneobursitis* or exostosis, often associated with flatfoot, requires treatment of the causative condition. A painful bursa or exostosis should be cut down upon and removed.

Hallux Rigidus.—Rigid great toe with flexor spasm requires treatment of the fallen arch or other causative factor. Proper shoe, cure of the arthritis, and rest are essentials.

Pigeon-toe (Inward Rotation of the Feet).—This condition when not associated with club-foot, often is so extreme as to require treatment. The causative factor should be sought out and remedied. Bow-legs, congenital talipes or coxa vara, may be the causes which require attention. Cases in which the feet are turned in to compensate for or relieve weakness of the plantar arch or knees require treatment of these conditions. Mild cases, in which these causes do not exist, may be cured by making the outer border of the shoe slightly thicker than the inner border. When the rotation is due to tension of resisting fascia or ligaments this may be corrected by forcible manipulation under general anesthesia. Mild cases tend to spontaneous correction as the child grows older. Apparatus, consisting of two elastic straps attached to the middle of a waist belt at the back, one descending spirally around each leg and attached below to the outer border of the sole of the shoe, may be worn. In intractable cases osteotomy of the tibia and fibula or of the femur, followed by fixation in the desired position, must be resorted to.

Swollen Feet.—This symptom when due to disease of the heart, kidneys, or to venous obstruction requires treatment of the causative condition. Swelling incident to long standing or walking may be relieved without confinement by means of even gentle pressure. This may be applied by an elastic bandage extending from the toes to the lower leg or by adhesive strips evenly covering the foot (see Bandaging of Foot, page 773). Massage is always useful.

Sore Feet.—The soreness which comes from much walking with feet not used to it, the feet becoming tender, painful, swollen and somewhat inflamed, is best treated by bathing and rest. But if the individual must go on, one of the following treatments is useful: The feet may be rubbed night and morning with alcohol containing 1 or 2 per cent. of salicylic acid. The tender parts may be painted once or twice daily with a saturated solution of picric acid or 2 per cent. chromic acid solution. After washing and drying the feet they may be sprinkled with a powder made of 30 Gm. powdered chalk and 0.12 Gm. (2 grains) salicylic acid. Or the feet may be soaked in a vessel of cold water to which has been added salt, alum, tannic acid, permanganate of potash, or saltpeter. A wash of cold tea is also effective.

Cold Feet.—The tendency to cold feet is due to defective circulation of blood or to retention of moisture of the foot. The general health should be improved. Massage and exercise of the feet by walking are most useful. The vessels should be kept warm especially where they approach the surface at the popliteal space, ankle and dorsum of the foot. Woolen and cotton stockings absorb the moisture, retain it, and keep the feet cold. Unna advocates treating the stockings with some impervious material which prevents absorption. Stockings which can be written on with ink do not soak up moisture. He gives a formula for sizing stockings: 12 parts collodion, 4 parts colophony, 4 parts castor oil, 16 parts alcohol, and 64 parts ether. The shoes should be

roomy. Two pairs of stockings should be worn. Ankle warmers should be added to the equipment. The lining of the shoes should be glazed with the same mixture. The skin of the feet should be greased.

Shoes.—Many of the diseases of the foot are caused and all of the diseases of the foot are aggravated by the ordinary shoes. The shoe should serve to protect the foot from physical injury and the individual from dirt. In our so-called civilization it inflicts physical harm and serves as the chief agent for carrying into the domicile the excretions of animals, the expectorations of the diseased, and the varied putrid matter of the highway. Wise and cultured people wear shoes that do not inflict physical harm upon the feet, and by leaving them at the threshold make them to serve the scientific purpose of excluding from the home the filth of the streets.

The shoe should correspond to the shape of the foot. The normal foot is somewhat triangular—broad in front, narrow behind. The plantar arch rests upon the ground at its outer edge, and at its front and rear. This gives the bearing surface of the foot an outward curve which should be accommodated by the shoe. The outer border of the shoe should be widely curved outward; the inner border may be curved in the same direction or straight.

The conventional shoe of Christendom restricts the normal movements of the foot. The sole is narrower than the plantar bearing surface. The foot rests partly on the sole of the shoe and partly on the upturning leather at the sides. It bears, therefore, upon a transversely curved surface, having a downward convexity—just the opposite of the curve of the transverse arch of the foot. This tends to throw upward the outer and inner borders of the foot, and, accordingly, to break down the transverse metatarsal arch. The great toe is forced outward and ceases to be a factor in pressing the ground and supporting the plantar arch, and commonly becomes, like the rest of the toes, a weakened excrescence. It becomes incapable of strong plantar flexion and ceases to functionate as a useful member. The forefoot, anterior to the transverse metatarsal arch, instead of seeking the ground tends to turn upward. The sole of the shoe is prone to curve upward like a rocker. The bones of the foot being so restricted and supported in their motion the ligaments are not required to functionate naturally. All of the muscles of the foot are hampered in their movements and become atrophic. The foot becomes weak; or, rather, is never permitted to become strong.

The heel is added to the shoe supposedly to throw the body somewhat forward and make walking easier, but it is unnatural and unnecessary. It is conceived in hypocrisy. Its real function is to add to the apparent height of the wearer. The heel of women's shoes is commonly so high that it causes the front of the foot to be crowded forward into the shoe, still further squeezing the forefoot and contributing enormously to the inefficiency of women. If there is any one thing which stamps us as uncivilized it is the shoes of our women, which would prompt us to look with pity upon any other people who affected such things.

The shoe is stiff, its shank is hard, the sole is thick; and as a result, movements are awkward and attitudes unnatural. The common shoe causes corns, bunions, ingrowing toe nails, hammer-toe, flatfoot, and many of the other diseases of the foot; and aggravates most of the weaknesses which the foot suffers. By the time the wearer reaches a philosophic age he finally rebels, and with weak and distorted feet seeks to express his revolt by wearing broad-toed shoes—called "old men's shoes"—which usually are apparently broad-toed, as to the part of the shoe which is not occupied by the foot, but which distort the foot as of yore—indeed, it is quite doubtful if

the unnatural feet would feel at home in natural shoes. And so the pathetic figure limps to his grave, with the warped and misshapen relics of two organs, so wonderful in their origin and once so perfect in their functional possibilities as to challenge the amazement of the human mind.

The individual unless he be a strong character, is a victim of the social system which bends him to conformity. Shoes are made in the pecuniary interest of the manufacturers and dealers, who find it to their advantage to encourage the worst impulses in the consumer—the impulses which make for "styles," "fashions," and conventionalities, and a longing to seem to have feet unlike those of working people. In the meantime, in the absence of the prophylactic social conscience, surgery is evoked to repair the damages.

The proper shoe should have a sole as broad as the expanded weight-bearing foot (page 485). The lateral expansion of the foot should not be checked by the sides of the shoe. The shape of the shoe should conform to that of the foot—broad in front and narrow behind. It should be broad enough to allow slight adduction of the great toe. The sole of the shoe should be of flexible leather so that the toes may actually play their normal rôle in plantar flexion with each step. The shoe should be long enough to permit full extension of the toes without their impinging upon the front of the shoe.

The heel should be thicker than the sole, only to provide for a little more wear, and not for postural purposes. The rubber heel is a distinct advantage. The uppers should be pliable and soft, and not stiff. It is highly important that the proper shoes be provided for the growing child.

The shoe is such an important adjunct to surgical treatment that its discussion has seemed necessary. It is a causative factor of magnitude in many surgical diseases; and it may be made a potent instrument for the prevention and treatment of an equal number of surgical ills. It will continue a human menace until the time comes when the people are ready to take the matter in their own hands and for themselves make shoes for the purpose of wear, and cease to depend upon shoes which have been made for the purpose of profits.

AMPUTATIONS

Amputation is the cutting off of a member or part of a member in its continuity. Amputation at a joint is called disarticulation. The operation is a last resort. It is done for such conditions as: (1) injury in which the vitality of the limb is destroyed; (2) injury in which the usefulness of the limb is forever lost and the useless member is destined to be an undesirable appendage; (3) gangrene; (4) tumor which can only be removed by removing the limb; (5) intractable diseases, such as ulcers, disease of bone, elephantiasis and snake-bite, in which the interest of the patient is served by the saving of time and by the cure of the disease by amputation; (6) incurable paralysis of all of the muscles of a limb in cases in which a useful prosthetic apparatus can be substituted for the paralyzed limb which is an undesirable appendage; and (7) supernumerary members.

Amputation as a Plastic Operation.—Let no surgeon think that amputation can be reduced to a matter of rules, or that rules can be made simple and automatic. Rare judgment is required in determining when to amputate, how to amputate and where to amputate. Indeed, a question which will often confront the surgeon is, Is amputation required at all?

Amputation should be regarded as a plastic operation rather than as the lopping off of a member. If there is living tissue beyond the place of amputation, the necessity for the operation should be questioned. The possibilities of plastic surgery are so great that the surgeon, before amputating, should ask himself the question, Can I not excise the diseased part and supply the deficiency by grafting? If the disease is of the bone alone, amputation is utterly unjustifiable, because bone transplantation is so effectively accomplished. In the case of tumor of the bone, the diseased segment of bone should be excised, the defect filled by a graft of bone, and the wound closed. For precisely the same reason, the surgeon should ask himself the question with regard to other structures. Bone, skin, muscle, tendons, fascia, blood-vessels, nerves, and joints are all capable of restoration and grafting.

Bone, skin, and fascia may be transplanted from other parts. Muscle and tendon may be turned down and attachments changed. New tendons may be constructed. Vessels may be transplanted and grafted. Nerves may be grafted and bridged. Joints may be reconstructed, grafted, or made by interposing fascia between bones.

The principles of plastic surgery may not only be invoked to save the limb, but if the limb must be sacrificed plastic methods may be employed to make the loss as small as possible. The ancient practice in amputations has been to make a sacrifice of perfectly sound limb—muscle, vessels, nerves, and bone—in order to get skin to cover the stump. The competent surgeon must ask himself the question, Can I not get this skin elsewhere, and save the muscle, vessels, nerves, and bone which must be sacrificed if I amputate higher?

It should be borne in mind that when a limb is amputated for disease other than gangrene, the blood supply is usually more than adequate to nourish the stump. It is adjusted to nourish not only the stump but all of that part beyond which has been removed. For this reason the transverse or flapless operation is to be considered always; and the covering of the bone end undertaken with a transplanted flap of skin. In uninfected cases the

transplantation may be done at once. In infected cases it may be undertaken later.

It should be borne in mind that it is easier to cut off a limb than it is to put it back or to reconstruct a new one. Rarely is it necessary to make a finished operation at the first setting. To save as much tissue as possible is usually a good rule to follow. Moreover, the surgeon should remember that the higher the operation the greater the shock. A few inches one way or the other often determine the difference between life and death. A well-covered and symmetrical stump on a dead patient is never a beautiful stump. And so, while the typical methods of amputation are described in the following pages, the surgeon should ever have in mind the lessons to be found in the chapters on plastic surgery and the grafting of tissues, and make his own variations to suit the circumstances of each individual case and his own skill.

Instruments.—The instruments used in typical amputation are some form of constriction or tourniquet to control bleeding, amputating knives, retractors, forceps, hemostatic clamps, periosteal elevator, saws, bone forceps, ligatures, scissors, and needles. In some amputations special instruments are used.

Preparation of the Patient.—There is shock after all major amputations. The nearer the trunk the amputation is done the greater the shock. The shock increases with the number of nerve cells injured and the amount of blood lost. It is greater in amputations of the lower extremities, greater when done for injury than for disease, greater in men than in women, and greatest between the ages of five and fifteen. Everything should be done to minimize it. An amputation at or above the knee in a sensitive person is a serious operation. The amputation of both thighs is an operation of great gravity, and often fatal unless the utmost pains to prevent bleeding and shock are taken (see Prevention of Shock, Vol. I, page 213).

The local preparation for amputation is the same as in other parts. The patient should come to the operating table with the skin prepared so that all that remains to be done is to remove the antiseptic protective dressing. All of the limb below the incision should be kept covered with an aseptic dressing.

Time of Operation.—Amputations done for disease may be set for the time which is best for the patient and the convenience of the surgeon. Amputations done for injury are different. *Primary amputation* is that which is done immediately after the injury. *Intermediary amputation* is done during the course of healing of the injury. *Secondary amputation* is that which is done after the wounds are healed. Primary amputation may be done if the patient is not appreciably shocked. If the condition of the patient is such that operation is contraindicated on account of shock or loss of blood, the constitutional condition should receive immediate attention (see Shock, Vol. I, page 213; and Acute Anemia, Vol. I, page 343). When treatment brings reaction from these conditions, amputation may be done during the reactionary period, precautions being taken not to add more shock or anemia. This period of reaction is usually within the first thirty-six hours. In most cases, so badly injured that amputation is imperative, if reaction has not been secured within thirty-six hours, *nerve blocking* should be done and the amputation proceeded with.

Anesthesia.—Anesthesia is necessary to prevent shock and pain. The general anesthesia best adopted to amputations is *nitrous oxid* and *ether*. In amputations of the thigh and at the shoulder-joint, and in all cases in which the general condition of the patient predisposes to *shock*, the main nerve trunks should be *blocked* from transmitting central impulses by injecting them

with cocain, eucain or other anesthetic agent. This is done during the operation when the nerve is exposed and before it is cut. It has been shown that even when the patient is under a general anesthetic, division of the great nerve trunks produces shock unless they are first locally anesthetized.

As a result of this knowledge many surgeons have developed such skill in local anesthetization that they are able to perform major amputations without employing a general anesthetic (see Local Anesthesia, Vol. I, page 127).

In some cases spinal anesthesia may seem indicated.

Positions at Operation.—The *patient* should usually be placed on his back near the side of the operating table. For amputations of the upper extremity the arm is held out at a right angle to the body. For amputations of the leg, the limb may be abducted from the table. In amputating the thigh, it is most convenient to place the patient with the pelvis resting at the foot of the table; the sound leg rests upon an extension, another table, or a chair; while the diseased leg projects over the foot of the table and is held by an assistant.

Amputation in the *ventral decubitus* is to be preferred in some cases. R. Finochietto (Annals of Surg., May, 1915) has directed attention to the value of this position in amputations of the leg. This gives better control of the flexor muscles which constitute the chief mass. The stump is brought into view without moving the thigh. In the dorsal decubitus the hip must be flexed and the thigh lifted in order to make the necessary manipulations. Patients seem to bear anesthesia well in the ventral position.

The *surgeon* should stand facing the limb in such a position that he grasps the limb with his left hand between the place of incision and the trunk. Thus he stands at the outer side of the right extremities and at the inner side of the left extremities. These rules are not imperative, but should be modified to suit the exigencies of the case. In high amputations of the left limbs the rule will be modified.

Saving of Blood and Prevention of Bleeding.—Hemorrhage should be prevented by excluding from the limb as much blood as possible. This is accomplished after the patient comes on the table: (1) by elevation of the limb and invoking gravity to remove the blood from the limb and send it back into the body. After a few moments of gravity, the (2) rubber bandage of Esmarch should be applied (see Control of Hemorrhage, Vol. I, page 334).

After the constricting band has been applied it should be covered with sterile cloths. In the absence of a rubber bandage, a woven fabric bandage may be used.

In high amputations at the hip and shoulder where constriction is difficult, digital compression of the main artery by an assistant was formerly much employed. In such cases it is more satisfactory to expose the main artery and tie it as a preliminary step. Compression of the abdominal aorta, after the method of Momburg (Vol. I, page 363), is useful in amputations at the hip. Pins, thrust through the soft tissues at the shoulder and hip, are used to keep the constricting elastic tubing from slipping downward.

On account of the traumatism which the elastic bandage inflicts and the subsequent danger of paralysis and gangrene in limbs of poor vitality, it may be dispensed with. If the limb is held elevated for from three to five minutes most of the blood runs out of it, and the constricting tourniquet may then be applied. The outflow of blood may be expedited by stroking the limb with the hands. In cases in which the constriction of the tourniquet would be dangerous, the limb may be elevated, the main artery tied with the limb still elevated, and the amputation proceeded with. In such a case I have stood on a stool and

amputated the leg while my assistants held it elevated, without the use of elastic bandage, tourniquet, or preliminary ligation —simply clamping each vessel as it was exposed in the course of the operation—with as little loss of blood as obtains under any of the compression expedients.

In operating below the elbow or knee the constriction is best applied just above the joint. In operating in the thigh or upper arm the constriction should be applied as near the trunk as possible.

The use of the *sphygmomanometer* in connection with the constricting band enables the surgeon to regulate the pressure more accurately. The pneumatic band for this purpose permits the application of just enough pressure to close the vessels and no more. The tissues may thus be spared the damage which results from too much pressure.

After the amputation *all visible vessels should be clamped* with hemostatic forceps and tied, care being taken to tie only the vessel and not to include nerve trunks in the ligature. As a result of the elastic compression, vessels may be so collapsed as to seem incapable of bleeding, but the reaction may dilate them and bring about serious hemorrhage, unless they have been ligated (see Hemorrhage, Vol. I, page 334).

Infusion of saline solution or blood is often necessary, particularly in amputations of the thigh and hip. These patients have often lost blood as the result of the accident. The infusion of as much as 1500 c.c. of saline solution may be made directly into the femoral vein in as short a time as two or three minutes, if necessary. Savariaud (Bull. de l'Acad. de Med., July 13, 1915), who advocated this method, noted that the rise in blood-pressure can be seen in the behavior of the ligated artery which is directly under observation. Another advantage is that the small vessels begin to bleed and can be located and tied.

Division of Tissues.—Before making an amputation it is necessary to determine two points; the lower limit of the operation, or skin incision, and the upper limit, or the bone incision. The surgeon should picture in his mind where these are to fall. It should be remembered that the skin, connective tissue and muscle are elastic, always slightly on the stretch, and retract as soon as divided. In most situations, if a limb is cut off by incision through all of the structures at the same level, the end of the stump will represent a cone with the bone sticking out at the apex. The muscle retracts the more the farther it is from the bone, and the skin retracts the most. Because of this retraction of the soft tissues, the skin must be divided lower than the muscle, and the muscle lower than the bone. This difference should not only be enough to counteract the retraction—for if that were done the result would be an even stump with uncovered bone in the middle —but the soft tissues must be divided so much lower as to provide a flap to cover the end of the bone without tension. There must, therefore, be a certain ratio of *difference between the level of the skin incision and the bone incision.*

In considering *amputations at joints*, there must be enough tissue between the upper limit of the disease and the joint to provide covering for the bone. If there is not, instead of a disarticulation, an amputation above the joint must be considered.

The *length of the stump* is determined by the amount of bone left. It is usually desirable that the stump should be as long as possible. The line of division of the bone is determined by the amount of soft tissue available to cover the bone. The line of incision through the soft tissue, therefore, should be as near to the disease as is consistent with viability of the flap and removal of all of the disease. Exceptions to this may be found in am-

putations in which it would be possible to divide the bone just below a joint. In such cases it is often better to disarticulate at the joint than to leave a small distal fragment. This must be determined by other exigencies. There are many forms of amputation but the surgeon should not hold himself too closely to prescribed lines. Typical amputations are intended only as guides and to suggest lines of election. More tissue may be saved in some cases by making irregular and atypical flaps.

The possibilities of **grafting upon the stump** to lengthen it are very great. In some cases in which it has been desirable to make the stump as long as possible I have left the bone longer than the flap, and transplanted a flap from elsewhere or turned down a pedunculated flap from above. Such grafted tissue may embrace not only skin and fat but other tissues also. It is possible in cases in which more soft tissue than bone is available, to transplant bone from elsewhere. We therefore have at our command possibilities for building up a stump which terminate only at the complete restoration of a member. If the blood supply is inadequate because of its terminal position, because of the amount of scar tissue present in an amputated stump, or because of thrombosis or other disease of the vessels, this may be overcome by the transplantation of tissue containing a blood-vessel large enough to be anastomosed with the main vessel of the stump. When we now turn to the possibilities of what can be done in the fields of a blood-vessel anastomosis, nerve suture tendon suture and transplantation of bones and joints, the reconstruction or restoration of amputated members becomes only a matter of the surgeon's capacity for taking pains.

Amputations in the presence of infection require especial consideration. If there is a crushing wound or a traumatic amputation with serious infection, there is added an extra hazard to the case by amputating through the healthy tissues above the wound, as such an amputation often means infection of a fresh new wound. It is best in these cases not to lose the advantage of the protective infiltration of the tissues which the inflammation in the wound has evoked. The flaps within the infected zone should be trimmed, and the bone amputated as high as possible without opening up any fresh soft tissues. The bone-end should be painted with iodin to excite exudation, and the wound packed with gauze. This method of treatment is of especial importance in infections such as with gas bacillus (see Infections and Inflammation).

When it seems best to proceed with an amputation and make a new wound in the presence of infection the flaps should not be sewed but the wound should be packed with gauze and left wide open.

Size of Flaps.—The amount of soft tissue necessary to cover the bone may be calculated as follows: In a circular amputation, the skin incision should be below the place of division of the bone a distance equal to three-fourths of the diameter of the limb or one-fourth of the circumference of the limb. In operations with a single flap, or two flaps of unequal size, the total length of the one or two flaps, below the bone, should be 1½ times that of the diameter of the limb or one-half of the circumference of the limb. Roughly the diameter of the limb is one-third of the circumference. These are not absolute rules. The skin and superficial fascia should be divided a little lower than the muscle. If the place of the bone division is known, the line of skin division may be calculated by these rules. If the place of the skin division is known, it is customary to make the soft-tissue flaps, retract them, and then divide the bone at a point which will allow suture of the flaps over the bone without tension. This is very important, as some swelling and infiltration take place after operation and increase the tension. Allowance should be made for this.

In the lower part of the thigh or the lower part of the arm, where there is the greatest contractility of the soft parts, a greater allowance than the above may be made. Here the total length of the flaps may be twice the diameter of the limb or two-thirds of the circumference of the limb; and in circular amputations the skin incision may be below the bone division a distance equal to the diameter of the limb or one-third of the circumference. In tissues of lesser contractility, as in the hand and foot less than the above allowances may be made (Fig. 1875).

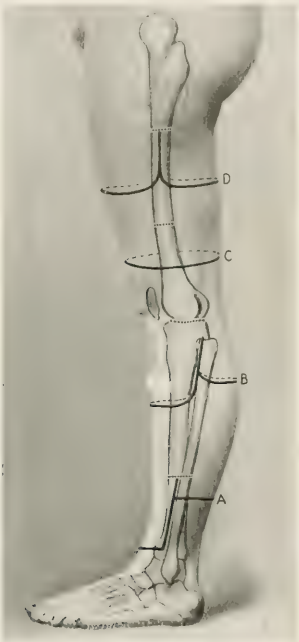


FIG. 1875.—RELATIONS OF SKIN INCISIONS TO BONE INCISIONS IN AMPUTATIONS. The bone incision is indicated above each skin incision.

Lines of Incision.—The usually employed lines of incision are for circular amputation, equal flap amputation, unequal flap amputation and amputation with irregular flaps (Fig. 1875). There are also incisions of special designation which will be described under the several parts.

Technic of Making Flaps.—*Incision of the skin* is made while the surgeon with his left hand grasps the limb and retracts the skin upward. In the thigh this retraction is best done by an assistant. This is important in order to provide for later contraction. The long knives once much used were of value when rapidity was the main thing. They are now used only in

circular amputations. The long knife has a blade the length of which is equal to 1½ times the diameter of the limb. It is grasped in the fist, the surgeon's arm being under the patient's limb, the point of the knife directed toward the surgeon, and the cutting edge resting horizontally upon the limb (Fig. 1876). The incision is begun near the hilt, and the knife

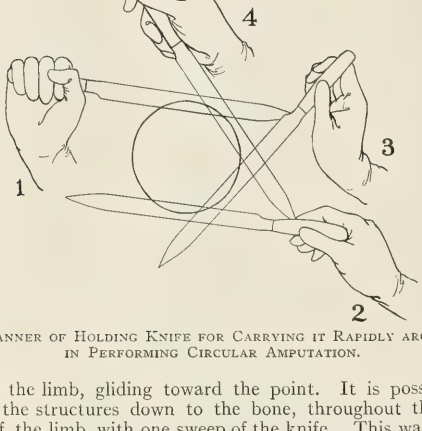


FIG. 1876.—MANNER OF HOLDING KNIFE FOR CARRYING IT RAPIDLY AROUND THE LIMB IN PERFORMING CIRCULAR AMPUTATION.

swept around the limb, gliding toward the point. It is possible to make a division of the structures down to the bone, throughout the whole circumference of the limb, with one sweep of the knife. This was done before the days of anesthesia. It is better to carry the division only through skin and superficial fascia for a distance of three-fourths of a circle, then remove

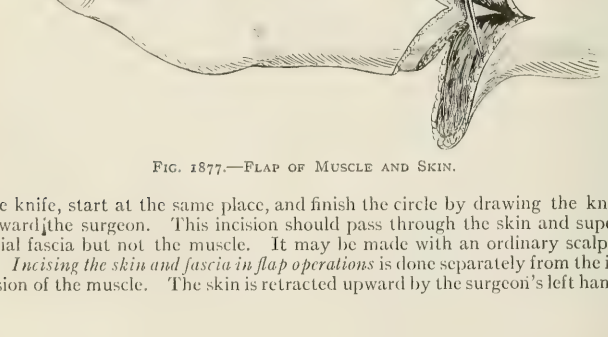


FIG. 1877.—FLAP OF MUSCLE AND SKIN.

the knife, start at the same place, and finish the circle by drawing the knife toward the surgeon. This incision should pass through the skin and superficial fascia but not the muscle. It may be made with an ordinary scalpel.

Incising the skin and fascia in flap operations is done separately from the incision of the muscle. The skin is retracted upward by the surgeon's left hand.

A scalpel is held between the thumb on one side and the tips of the four fingers on the other. The joint of the scalpel penetrates as far as the muscle at the upper limit of the flap. The incision is then made down to the muscle, marking out the flaps. The division of the skin and fascia should be at a right angle to the skin surface. Flaps should generally be about square with the corners rounded. A circular amputation may be converted into a flap amputation by making lateral incisions and rounding the corners.

Turning back the flap should be done in such a way as to provide covering for the bone and disturb as little as possible the blood supply to the skin. The skin and superficial fascia should be dissected back to the line at which the muscle is to be divided. This is done by lifting up the skin and fascia gently and touching the surface of the muscle with the point of a knife wherever the fascia seems attached. The fascia carries the vessels to the skin and should be traumatized as little as possible. This dissection should be carried only up to the line where the muscle is to be divided.

The place of dividing the muscle will depend upon whether muscle is to be used to cover the bone or not. If the end of the bone is to be covered with skin, fascia and muscle, the fascia is not dissected back but the muscle is divided in the same line as the skin. The knife as it outlines the flap sinks deeply into the muscle. It is not necessary to reach the bone with the first incision. It should rather be a dissection. The muscle should be divided obliquely at the lower border of the flap so that it is thinner there than at its base (Fig. 1877). If the flap is not to include the muscle, a circular division of the muscle is made after enough flap has been dissected up to cover the stump.

Circular amputation is the quickest and most useful form of amputation. The skin, having been divided circularly, is again retracted upward, exposing the muscle in the wound. The muscle is divided by a sweeping incision, the same as the skin (Fig. 1878). This division of muscle should be at a level of the retracted skin and should involve about one-half of the thickness of the muscle. In order to secure even contraction some muscles will be divided completely and others at a different level or obliquely. The superficial muscle layers having been divided, they are retracted upward with the skin, and the deeper layer of muscles is divided still higher (Fig. 1879). This carries the operation down to the bone, enough of which may be left free to provide for a periosteal flap or other bone plastic. By dividing the skin at the lowest point, the outer layer of muscles higher, and the deep layer of muscles still higher, an infundibulum is formed having the sawed bone at its apex. This provides a muscle-skin covering for the end of the bone, and secures the best nourishment for the skin (Fig. 1880).

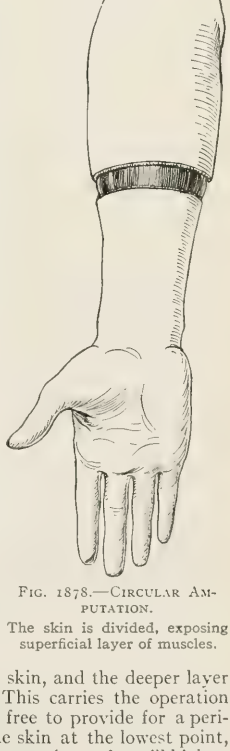


FIG. 1878.—CIRCULAR AMPUTATION.
The skin is divided, exposing superficial layer of muscles.

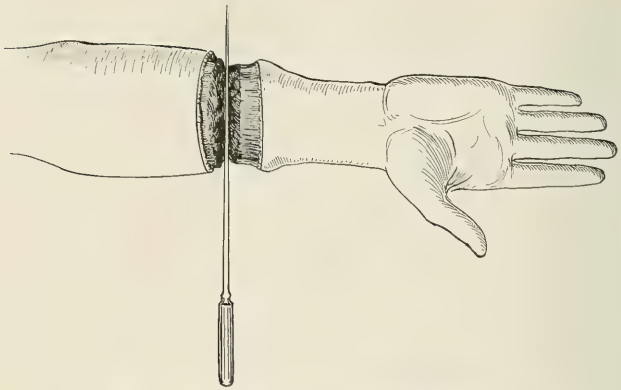


FIG. 1879.—CIRCULAR AMPUTATION (SECOND STAGE).
Dividing deep layer of muscles after superficial layer has been divided.

FIG. 1880.—CIRCULAR AMPUTATION, SHOWING FORMATION OF INFUNDIBULUM.

In the event of haste being necessary the muscles may be divided with one sweep of the knife in all the layers. Another modification of the circular amputation consists in rolling back a cuff of skin and fascia as soon as they are divided. To facilitate this in the thigh a longitudinal lateral incision in each side of the skin and fascia may be necessary (Fig. 1881). The corners should be rounded off.

The *advantages of circular amputation* are many. It is the most easily performed operation; and inasmuch as the body weight is easily removed from the end of the stump, in most instances, the fact that the scar is there is quite immaterial. In fact, that is the best place to have the scar in most amputations. The worst place to have the scar is where it will suffer friction in walking, and that is on the anterior surface of the leg or thigh, for the end of the stump is used chiefly for leverage in throwing the leg forward and balancing the body as the body moves forward. The weight of the body is usually borne upon the bony prominences about the knee in amputations

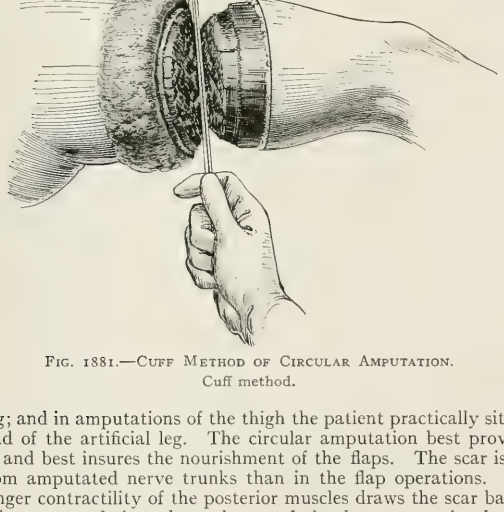


FIG. 1881.—CUFF METHOD OF CIRCULAR AMPUTATION.
Cuff method.

of the leg; and in amputations of the thigh the patient practically sits on the upper end of the artificial leg. The circular amputation best provides for drainage and best insures the nourishment of the flaps. The scar is farther away from amputated nerve trunks than in the flap operations. Usually the stronger contractility of the posterior muscles draws the scar backward, and in the course of time the end scar of circular amputation becomes a posterior scar.

Amputation with flaps is made either with or without retaining the muscle in the flap. The former is to be preferred. The muscle is retained in connection with the skin. As the flap is dissected up the muscle is divided obliquely so that the full thickness of the muscle is retained at the base of the flap.

Cutting *flaps by transfixion* is done after the skin and fascia have been divided and the flaps thus outlined. A long amputating knife is used,

having a blade the length of which is at least 1½ times the diameter of the limb. This is entered at the upper end of a lateral arm of the skin incision, at right angles to the bone. The point is then caused to pass in front of the bone and, by elevating the handle, the point is made to emerge at the upper limit of the lateral incision of the opposite side (Fig. 1882). With a saw-like motion the knife follows the line of the anterior flap, thus cutting through the muscle from the bone toward the skin. The same is done posteriorly in connection with the posterior flap. It is desirable that the great vessels and nerves should not be transfixed and split longitudinally, but should be divided nearly at a right angle.

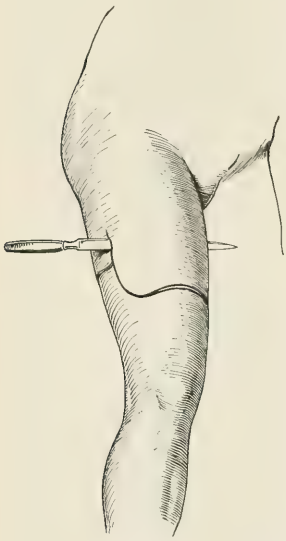


FIG. 1882.—CUTTING FLAPS BY TRANSFIXION.

The skin flaps are shown marked out. The knife is caused to pierce the thickness of the limb and follow the line of the skin incision.

Treatment of the Bone.—*Musculo-periosteal flaps* to cover the end of the amputated bone are most commonly employed. Such a covering is supposed to seal the medullary canal and provide nourishment for the end of the bone, thereby serving to prevent atrophy of the bone, and promoting its fixation to the terminal soft tissues.

As the dissection of flaps approaches the bone, care should be taken to prevent separation of the muscle from the periosteum. The division of muscle should come down to the bone at a point below the saw line equal to at least half of the diameter of the bone. The flaps should then be retracted gently so as not to separate the muscle from periosteum. The periosteum, with the nearer muscular fibers, is then divided circularly around the bone by means of a strong knife which should cut into the bone. With a sharp periosteal elevator the periosteum, with the muscle lying upon it undetached, is elevated from the bone as a cuff.

How much value turning back this periosteal cuff has is doubtful. Often the periosteum is elevated in shreds. It is entirely conceivable that it does more harm than good. Most amputations through the shaft in which the periosteum has thus been elevated, later develop painful bony projections and pointed stumps. Surgeons are now abandoning this periosteal operation. Many believe that a simple transverse amputation of periosteum and bone is just as good; some believe it is better. Osteoplastic and tendoplastic treatment of the bone-end are superseding the periosteal flap. Even the aperiosteal method is, perhaps, to be preferred. In the present state of our knowledge the surgeon is justified in ignoring all of these fancy expedients, and simply sawing off the bone through the periosteum.

Division of the bone now follows retraction of all of the soft parts. Two small towels or strips of muslin are employed for retracting purposes. They are crossed over the flaps and leave only the bone exposed. Instead of the

two pieces of cloth, a split piece of muslin may be used (Fig. 1883). Metal retractors are also useful for this purpose. The especially prepared split retractors are best (see Amputation Retractors, Vol. I, page 49).

In the leg and forearm where there are two bones, in addition to the two strips of muslin, a third strip must be passed between the bones. Tension on these three pieces retracts the soft tissues away from the bone and permits sawing the bone without injury to the flaps. Instead of the three pieces

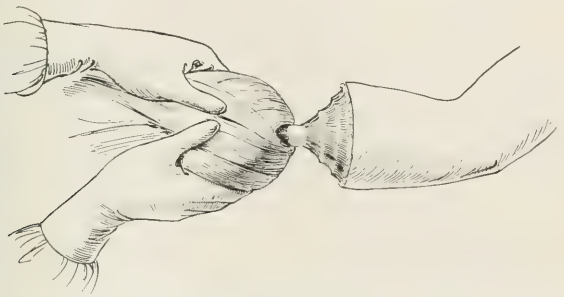


FIG. 1883.—METHOD OF RETRACTING THE SOFT PARTS WITH CLOTH RETRACTOR, PREPARATORY TO SAWING THE BONE.

of cloth a three-tailed piece of stout muslin may be used. This should be made of two thicknesses of muslin, or two pieces should be used, being drawn through in opposite directions (Fig. 1884).

For *sawing the bone*, the surgeon should stand on the right side of the limb. With his left hand spread out to aid retraction of the flaps he steadies the limb, and holds the saw in the right hand. An assistant holds the distal part of the limb which is to be sacrificed. This should be held at the same

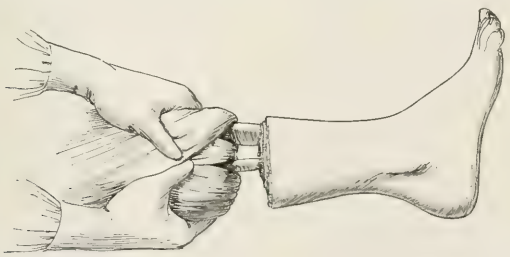


FIG. 1884.—RETRACTION OF SOFT PARTS IN LEG WITH THREE-TAILED RETRACTOR.

exact level as the proximal part of the limb. If it is held higher, the sawed ends of the bone will bind against the saw and make sawing difficult; if it is held lower, sawing will be made easier but the bone is apt to be splintered. The surgeon places the heel of the saw transversely upon the bone at the place where it is to be divided, and steadily and with firm pressure draws the saw toward him. This makes a groove. By holding the saw so that

the surfaces of the blade are at right angles to the surface of the bone the saw will not slip. If there is a ridge a prominence of the bone the saw should preferably be laid first upon this to facilitate making the initial groove. This groove may be deepened by lifting up the saw and repeating the first motion. The bone is then sawed through by a slow and steady back and forward motion. If the sawing is too fast it is possible that the heat generated may injure the bone. As the saw approaches the posterior aspect of the bone, the motions should be shorter and the pressure lighter, and the assistant should give especial attention to steadying the limb (Fig. 1885).

In the leg and forearm the saw is caused first to enter the nearer of the two bones, and before traversing this it is caused to fall upon the other bone. In some cases a wire saw or chain saw will best meet the requirements. In small bones, the saw should be thin and sharp; bone forceps are not to be recommended as they crush or devitalize the bone.

Where there is a sharp edge or point of bone, as at the anterior border of the tibia this should be sawed off so as to make an oblique bevel. Any spicule or sharp point of bone, left at the end of the saw cut, should be cut off.

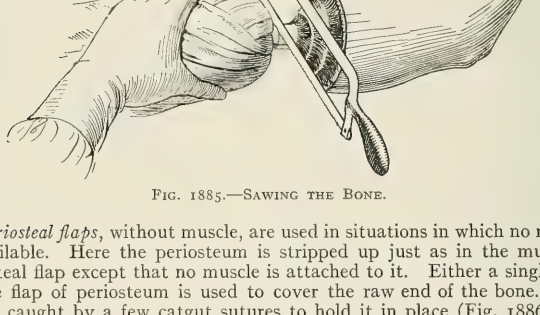


FIG. 1885.—SAWING THE BONE.

Periosteal flaps, without muscle, are used in situations in which no muscle is available. Here the periosteum is stripped up just as in the musculoperiosteal flap except that no muscle is attached to it. Either a single or a double flap of periosteum is used to cover the raw end of the bone. The flap is caught by a few catgut sutures to hold it in place (Fig. 1886) (see Comment on Musculoperiosteal Flaps, page 508).

A periosteal amputation was originally practised by simply sawing the bone across and paying no attention to the periosteum. This is the oldest form of operation. Many surgeons now are concluding that it is preferable to the periosteal method. Still, it leaves the raw edge of periosteum and the medulla to regenerate bone and render the stump sensitive. After Hirsch had noted that periosteal flaps were prone to throw out painful exostoses in the form of spikes and irregularities, he adopted the old transverse method of amputation. Bunge modified it by removing 1 cm. of the periosteum and medulla (Fig. 1887). This method has much to recommend it. (For Osteoplastic and Tenoplastic Amputations, see pages 524 and 526.)

Treatment of Blood-vessels.—The flaps should then be uncovered and retracted so as to expose the wound surface throughout its entire extent. This should be done in the best possible light. All of the important vessels should be identified. The larger veins and arteries should be clamped separately and ligated. The vessels should be sought for in the order of their

importance. This should be done systematically, and should be the surgeon's job. The vessels should first be looked for in their usual locations, the relations being identified. It will often be found that they have retracted between the muscles and must be drawn out of their connective-tissue beds. Pains should be taken that only the vessel is tied and that the ligature does not include other structures. Vessels which are large enough to be seen should be clamped and tied; it is not safe to trust to twisting. Bleeding from the bone is to be controlled by gently pressing in the bone to crush the canal; or the canal may be plugged with paraffin, wax or catgut. Rarely does the bleeding from the bone require any attention (see Surgical Arrest of Hemorrhage, Vol. I, page 334).

All the known and recognizable vessels having been tied, the constricting band is relaxed gradually. If serious bleeding follows, the constriction should quickly be reapplied, and the vessels more thoroughly identified. If the

FIG. 1886.—PERIOSTEAL FLAP FOR COVERING END OF BONE.

FIG. 1887.—AMPUTATION WITH REMOVAL OF PERIOSTEUM AND MEDULLA AT END OF BONE.

bleeding is slight, the bleeding vessels should be caught with clamps as fast as they appear, and ligated. General oozing may now be controlled by applying a hot towel to the wound surface. This should not be so hot as to cause necrosis of tissue. The flaps should be turned down over a mass of hot towels and held for a few moments while gentle pressure is made. Oozing which persists may be controlled by mass sutures.

Treatment of Nerves.—The nerves like the vessels should be known, and each nerve should be sought in its usual place. To prevent the involvement of the nerve-end in the terminal mass of scar tissue, the nerve should be caught with a clamp, drawn down and cut off high up so that its end shall retract well out of sight. In flap operations, in which the muscle is preserved in the flap, the nerve should be dissected out of the flap so that it shall not be subjected to the pressure of the end of the bone. Unless the nerve has been injected with local anesthetic above the point of division, it should

be traumatized as little as possible. Every insult to the nerve adds to the shock of the patient. If the patient is appreciably shocked the nerve should not be cut a second time until it has been anesthetized.

The *preliminary blocking of nerves* should be practised in all cases in which serious shock is to be feared. This is most simply done in the following manner: The amputation is proceeded with according to any of the applicable methods, excepting that incisions stop short of the main sensory nerves of the limb. Before an important nerve is reached, the wound is retracted, the nerve is identified and exposed, and injected with cocain solution (see Local Anesthesia, Vol. I, page 127). The operation then proceeds, the division of the nerve being postponed for fully five minutes after the injection.

In these cases in which the prevention of shock is a matter of especial consideration, it is still better to expose the nerve trunk by a separate preliminary incision and inject it.

Treatment of Redundant Tissues.—If a cinematic stump is not to be made, the ends of *tendon* appearing in the wound should be grasped with forceps, pulled down and cut off, leaving the stump to retract within the tendon sheath. Tags of *muscle* should be trimmed off evenly so as to eliminate any ragged appearance of the wound.

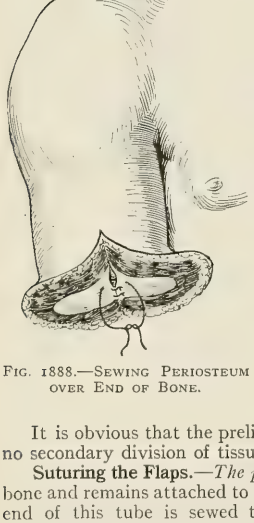


Fig. 1888.—Sewing Periosteum over End of Bone.

The *flap* may require trimming because of miscalculation in its shape or size. The flap should be long enough to cover the bone nicely without tension; in fact, it should cover it rather loosely.

This *trimming of flaps* and cutting tissues a second time is much to be deprecated. Every nerve that is cut adds so much more to the shock. The unskillful surgeon in one amputation may inflict as much shock as should ordinarily accrue in a double amputation.

A particularly unfortunate condition exists when not enough flap has been provided to cover the bone without undue tension. Here the bone must be reamputated at a level capable of being covered by the flap. This may mean that the bone division will be brought so near a joint that a disarticulation is advisable; and this may mean reamputation of the flaps.

It is obvious that the preliminary calculations should be so accurate that no secondary division of tissues should become necessary.

Suturing the Flaps.—*The periosteum* which has been stripped up from the bone and remains attached to the muscle is in the form of a tube. The distal end of this tube is sewed together, covering the end of the bone, with a continuous catgut suture. This is the prevailing treatment of the periosteum (Fig. 1888). Its value is doubtful.

If the flaps contain muscle, the *muscle* should be sutured over the bone end. This is best done with chromic catgut. The sutures should be applied in such a manner that dead spaces or cavities which may become filled with blood, are eliminated. This step in the operation is important also because additional covering of the bone is secured. It is most desirable: (1) that

there should be as little scar tissue as possible; (2) that the bone should be covered by a pad of soft tissue; and (3) that adhesion of the bone to the skin should be prevented. All of these ends are furthered by leaving muscle in the flap and by suturing it over the bone (Fig. 1889).

In the case of large muscular masses interrupted sutures should be used; in smaller masses the suture may be continuous. If the flap is large, more than one layer of muscle sutures will be required. The suture line of the muscles should in general have the same direction as that of the skin suture. This is the method pursued in *infundibuliform amputations* (Fig. 1890).

In *circular amputations* in which the muscle is divided at a level not lower than the retracted skin, the muscle retracts and cannot be used to cover the bone. Here the skin and fascia are the only heavy coverings to be sutured over the bone. In flap *amputations* the muscle should be quilted together as above described.

Suturing of the skin is best done in large wounds by means of silk or silkworm-gut interrupted sutures. The interrupted suture has the advantage that a suture may be removed here or there when occasion demands for later drainage. In smaller wounds continuous suture may be employed. Continuous suture may be an over-and-over suture of silk or a subcuticular suture of chromic catgut.

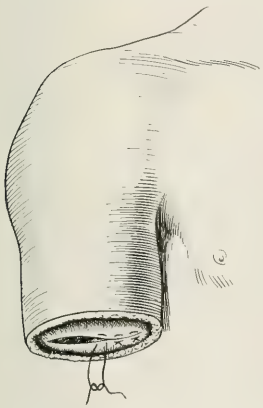


FIG. 1889.—SEWING MUSCLE OVER END OF BONE IN CIRCULAR AMPUTATION.

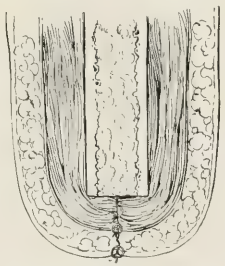


FIG. 1890.—SHOWING MUSCLE AND SKIN SEWED OVER END OF BONE.

In *circular amputations* it is best to suture the flaps so that the wound lies in an anteroposterior direction as this allows better drainage. In *flap amputations* the line of suture must conform to the flaps. In all cases in order to secure even approximation it is best to introduce first a suture in the middle of the wound. The two halves of the wound should then be divided into quarters by sutures in their middle. The four quarters may then be sutured with the assurance of even approximation.

Drainage.—In amputations of the thigh, hip, upper part of leg and of the shoulder, drainage is to be advised. This is because of the large wound surface and the large amount of secretion which is present. Drainage by means of a rubber tube or rubber tissue may be left in for two days. The more effective the elimination of open spaces by the deep sutures the less will be the necessity for drainage. The drain should emerge at the lowest part of the wound as the patient lies in bed. If drainage of the interior of

the wound cannot be brought out through a place in the skin wound equally low then a drainage opening should be made in the flap for the tube. The tube should be secured by a stitch or a safety pin.

In the event of operating through infected tissue or in the presence of an infected wound drainage should be used in all events. Seriously infected wounds should not be sutured at all but the wound packed with gauze and covered with a copious dressing.

Smaller surfaces such as in the forearm, hand, lower part of leg, and foot require no drainage unless infected. In these regions the flaps may be approximated throughout and the tissues left to absorb the secretions.

Dressing.—The wound and the stump should be enveloped in gauze. Over this should be applied a layer of absorbent cotton. These dressings should be thick enough to take up the ordinary wound discharges. The amount of dressing should not be so great that serious hemorrhage might be concealed by the dressing. This dressing should be held on by a bandage. The bandage should also hold a posterior splint of light wood. The object of this splint is to make it easier to lift the stump, protect it from injury, and to prevent muscular action. Slipping of the dressing should be prevented by a few strips of adhesive plaster.

The patient should be put to bed with the stump slightly elevated upon an inclined plane. A tourniquet should be within easy access so that it may be quickly applied in the event of hemorrhage.

The dressings should be changed on about the fifth day. This is because by that time they have become wet with secretion. A temporary drainage tube may be removed at the end of the second day without changing the dressings (see Bandages, page 735).

Results and Complications.—The *qualities of a good stump* are, that the bone-end should be well covered with a padding of soft tissue; that this covering should not be so tense as to have its circulation interfered with or so loose as to be unduly flabby; that the stump shall have a good blood supply; that it shall not be painful or tender; that the skin shall be adherent only at the cicatrix; and that it shall be regular and symmetrical.

Painful stump is usually due to the involvement of nerve trunk in scar tissue, the location of the nerve in such a position that it is pressed upon by scar or bone, or to neuritis. It may also be due to periosteitis or osteitis. Most painful stumps result from exostoses and conical degeneration of the bone-end. The treatment of painful stump is the treatment of the cause. If the nerve is compressed by scar tissue it should be cut down upon, dissected free and the end of the nerve removed. Often a bulbous nerve-end will be found. This helps in the identification of the nerve. In the case of smaller nerves the nerve cannot well be identified, and the treatment consists in dissecting out the painful scar and closing the wound.

Conical stump may be due to cutting the bone too long or the flaps too short, to making the flaps too thin, or to growth of the bone in the young after the amputation. In the young, therefore, especially in amputations of the arm and leg, because of growth from the upper epiphyses, the flaps should be made longer than in adults. Conical stump is treated by reamputation of the bone and reconstruction of the flaps.

Contraction of the tissues of the stump continues after the amputation. The flaps may be expected to contract about one-third of their area. This is the average degree of retraction of the *skin*. *Muscles* vary in their contraction. The longer the remaining stump of the muscle the greater will be the contraction. The muscular stump degenerates and the muscle fibers become replaced by scar tissue. If the muscle becomes attached to the soft

parts of the stump and is made to perform some function, the muscle does not disappear.

The *position of the stump cicatrix* is important. It should be so placed as to be the least exposed to pressure. The circular amputation leaves the scar directly in line with the end of the bone. However, in most well-done circular amputations, if a good thick flap is provided, the unequal contraction will usually draw the scar away from the end of the bone and toward the group of muscles which contract the most. This cannot always be counted upon, and so if it is desired to avoid a terminal scar, operations with unequal flaps are to be preferred.

METHODS OF AMPUTATION

The site of amputation and the method employed should be determined by the nature of the disease, the adaptability of prosthetic apparatus, and the hazard of the operation. As a general rule it may be said that the more of a limb that can be saved the better. This applies to soft tissues as well as bone. Cinematic amputations, whereby muscles are used to operate upon prosthetic apparatus, and osteoplastic operations, whereby the amputated bone-end is covered with bone to give a better bearing surface, will be described in connection with specific amputations.

The **circular method of amputation** is the simplest. Its principles have been described above (see page 505). It is employed especially in the arm and thigh. In a limb with rapidly tapering contour one or two longitudinal incisions must be added to the circular incision to permit retraction of the skin (Fig. 1891, *D*).

The **cuff method of amputation** is employed where there is not much muscle and the soft covering of the bone is thin, as at the lower part of forearm and leg especially in thin persons. The operation is begun as a circular amputation. After being divided the skin and fascia are turned back as a cuff. The tendons, muscle and other soft structures are then divided circularly down to the bone. The sawing of the bone, formation of the periosteal covering and the suturing of the flaps are the same as for the infundibuliform circular amputation. In the leg this operation is best improved by an osteoplastic connection between the two bones; and in the arm a tendoplastic operation is most desirable (Fig. 1881).

The **combined circular and flap amputation** is performed with two equal flaps of skin and fascia which may be lateral or antero-posterior. This is the amputation adapted to the greatest number of places, and most commonly used.

The saw line having been determined, two equal flaps are cut, with their lower borders a distance below the saw line equal to three-fourths of the diameter of the limb at the saw line. The base of each flap represents one-half of the circumference of the limb (Figs. 1875, *D*; and 1895).

The surgeon retracts the skin with the left hand and with a good-sized scalpel begins the incision on the anterior aspect of the limb. It passes downward and curves transversely away from him at the lower limit of the flap, when at the midlateral aspect of the limb the knife is removed and the hand is passed below the limb. The incision is then continued transversely to the posterior turn, thence upward at the posterior aspect of the limb to a point opposite the place of beginning. A flap of exactly the same size and shape is similarly cut on the side of the limb nearest to the operator. In cutting this flap, the vertical lines in their upper part have already been made in cutting the first lateral flap; and the knife does not need to leave the inci-

sion until it is completed. The two flaps of skin and fascia should be dissected back to a level a little above their bases. The flaps and the muscle are drawn upward and the muscle divided circularly. In a thick limb the superficial layer of muscle should be divided first. This should be retracted and the deeper layer divided at a higher level. Allowance for the musculoperiosteal flap be made in dividing the deeper layer. The operation is concluded as the circular amputation.

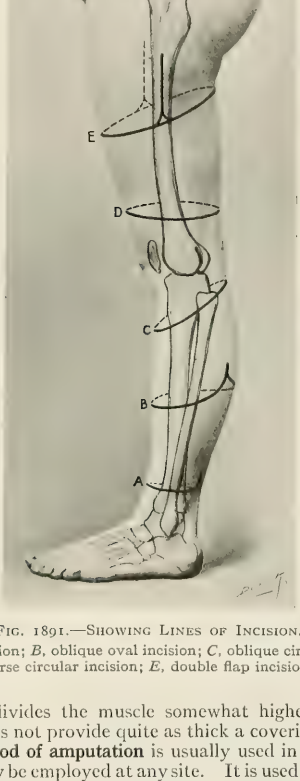


FIG. 1891.—SHOWING LINES OF INCISION.

A, Transverse oval incision; *B*, oblique oval incision; *C*, oblique circular incision; *D*, transverse circular incision; *E*, double flap incision.

This operation divides the muscle somewhat higher than the circular amputation, and does not provide quite as thick a covering for the bone.

The racket method of amputation is usually used in the operation of disarticulation. It may be employed at any site. It is used for disarticulation at the shoulder and hip and for disarticulation of the digits of the hand and foot. It is a modified circular amputation with one vertical line. The vertical incision begins above the joint. Before the incision is carried any farther, the joint may be examined, vessels may be ligated and divided, and

nerve trunks may be injected with anesthetic—all through the vertical incision. The vertical incision may be placed so that these steps may be taken (Figs. 1932, *A*; and 1947).

The incision then passes about the limb as a circular incision, returning to the vertical incision at the place of beginning. It is a circular incision, joined by a single vertical incision, or it may be described as an inverted T-incision with the angles rounded. The incision may be sutured in a single line in the direction of the queue of the racket; it may be sutured transversely at right angles to the queue or it may be sutured in both directions leaving a Y-shaped wound. If the wound is closed anteroposteriorly, it may be necessary to cut off a projecting tab of skin on the side opposite the queue, thus converting the amputation into a double lateral flap operation.

The oval method of amputation is the same as the racket method except that the vertical incision is not so long. It may be described as the circular

FIG. 1892.—EQUAL FLAP AMPUTATION.
This amputation is made with equal flaps of skin and muscle.

method with a vertical notch. The operation is used the same as the racket operation, and the wound is closed the same (Figs. 1930, *A*; and 1941, *C*).

Amputation by equal flaps of skin and muscle is used in fleshy parts between joints. It cannot be employed at joints. Two lateral or anteroposterior flaps are marked out. Each flap at its base represents half the circumference of the limb at the saw line and in length is equal to three-fourths of the diameter of the limb at the saw line (Fig. 1892). It is a combined circular and flap amputation with longer vertical incisions. The incision is made with a large scalpel and passes down to the muscle. The skin and fascia retract as soon as cut. At the upper margin of the retracted skin-fascia flap the muscle is divided obliquely. This division of the muscle should be less oblique in the vertical arms of the incision. The division of muscle should come down upon the bone below the saw line a distance equal to the

FIG. 1893.—AMPUTATION WITH UNEQUAL FLAPS.
In this amputation is shown a long anterior and a short posterior flap.

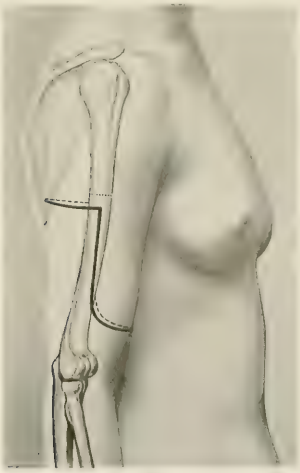


FIG. 1894.—AMPUTATION OF ARM BY SINGLE LONG FLAP.
This amputation is done with a single flap of skin and muscle.

diameter of the bone. At this point the periosteum should be circularly incised and the periosteum with the attached muscle detached as far up as the saw line. The bone is then divided. The musculoperiosteal flap is sutured over the cut end of the bone, the muscle is sutured separately and the skin flaps united (see pages 512 and 513).

This operation may be done as a circular amputation with infundibuliform incision of the muscles, and with the addition of two opposite vertical incisions.

Amputation by equal flaps of skin is done the same as the above except that the flaps consist only of skin and fascia. It is done in such parts as the lower forearm, lower leg, and fingers, where there is little muscle. The flaps are cut as above described, and retracted to a point a distance equal to the diameter of the bone below the saw cut. Here the muscle and other structures are divided down to the bone. The periosteum is cut through and elevated and the bone divided (see pages 508 and 510). The bone-ends are covered with skin and fascia but not with muscle.

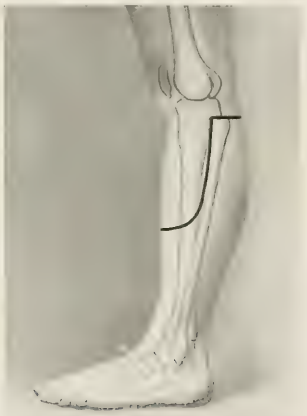


FIG. 1894*a*.—AMPUTATION OF LEG BY A LONG ANTERIOR FLAP.

Amputation by a single flap is of especial value in cases of injury in which material for a single long flap only is available, or in which by using such a flap a lower division of bone can be made than by the other methods. It is also employed in disarticulations of the foot and hand. Usually the operation consists in the part of a circular amputation involving only about one-half of the circumference of the limb. A flap having a length equal to one and one-half diameters of the limb at the saw line is then planned. Its width should be one-half the circumference of the limb. Muscle should be preserved if possible and treated the same as in the flaps of *skin* and *muscle*. If muscle is not available the amputation becomes one with a *single flap of skin*. The long flap is more apt to suffer from defects of circulation. In the event of infection sloughing of part of the flap is very apt to take place. If the muscle is retained in contact with the skin, better nourishment is insured (Figs. 1894 and 1894, *a*).

Amputation by unequal flaps has the advantage that the scar is not at the end of the stump. It may also be employed as an operation of expediency in cases in which destruction of tissue leaves material for two unequal flaps. The principles of the operation are the same as for the typical amputations. The flaps should preferably be of muscle and skin, but skin flaps alone may be used—or one skin flap and one skin and muscle flap. The total length of the two flaps should be equal to one and a half diameters of the limb at the saw line. The flaps may have any relative proportion between that of a single flap and two equal flaps. Usually one is twice the length of the other—a relative proportion of one-third and two-thirds (Fig. 1895).

Amputation by unequal rectangular flaps is similar to amputation by unequal rounded flaps. The operation is used in the lower part of the leg, and the longer flap is taken from the front. The bases of the flaps are at the level of the saw line. The length and breadth of the longer flap is equal to

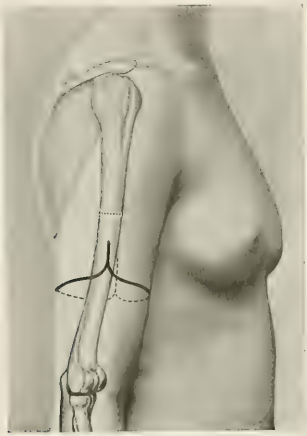


FIG. 1895.—COMBINED CIRCULAR AND FLAP AMPUTATION.
This is a circular amputation to which are added two lateral longitudinal incisions.

one-half of the circumference of the limb at the saw line. The breadth of the shorter flap is the same as that of the longer; its length is one-fourth that of the longer (Fig. 1896). The vertical incisions are made first and then connected by the two transverse incisions. The transverse incisions first pass only to the muscle. As the skin retracts, the muscle is incised at a level with the upper border of the skin wound. The muscle is divided down to the bone, and is then dissected away from the bone up to a point below the saw line, a distance equal to a half of the diameter of the bone. Here the periosteum is cut around the bone and the periosteum elevated with the muscle. The bone is then divided. The longer muscle-skin flap is bent over the end of the bone, and its end sewed to the end of the short flap, the muscle of the long flap being carried over the end of the bone and sutured to the

muscle of the short flap. The sides of the short flap are sewed to the sides of the long flap, and the bent-over part of the long flap is sewed to the remaining part of the long flap.

This gives a neat result. There is always a danger that the angulated flap may not have sufficient nourishment. The blood supply should be well considered and dressings should make but light pressure.

The elliptical method of amputation is a modification of the oval method, and is employed in the same positions. It is used chiefly for disarticulations. The lower end of the ellipse should preferably be taken from a region which supplies a thick covering. The operation may adapt itself to the local conditions and may thus be made in any direction. The skin incision is in the form of an ellipse, the upper part of the ellipse being on one side of the

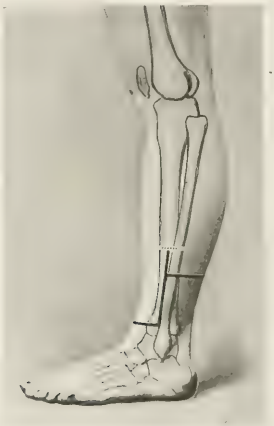


FIG. 1896.—AMPUTATION BY UNEQUAL RECTANGULAR FLAPS.
This amputation is done with a long rectangular anterior flap and a short posterior rectangular flap.

limb and the lower part on the opposite side. The upper limit of the ellipse should be just above the saw line or line of disarticulation. The lower limit should be on the opposite side of the limb at a distance below the saw line equal to about one and one-half diameters of the limb at the saw line. The two lateral incisions connecting these two points should pass evenly about the limb in a uniform curve (Fig. 1897).

The first line of incision should pass only through skin and fascia. After the skin has retracted, the muscle and other structures are divided down to the bone. The skin-muscle flap is dissected up to a point below the saw line sufficiently to give a periosteal flap and the bone divided. In cases of joint disarticulation, the periosteum is divided below the joint a distance equal to one-half of the diameter of the bone at the joint, and the periosteum with the capsular ligament and attached muscles are elevated. This flap of periosteum and capsule is then sutured over the articular surface of the

bone. The muscle is brought over this and sutured, and lastly the lower apex of the ellipse is brought up and sutured to the upper apex.

Irregular amputations have a wide range of application. The surgeon should not follow too closely the regular methods. Especially in accidents, flaps should be made in such shapes as the tissues provide. To attempt to make typical and regular flaps, in a case in which a strip of uninjured tissue might be employed and a lower amputation secured, is poor surgery. The ingenuity of the surgeon must be brought to bear in such cases. The cardinal rule should always be had in mind, that the lower the amputation the more useful the prosthetic apparatus can be made.

FIG. 1897.—AMPUTATION BY ELLIPTICAL INCISION.
The incision here shown forms a long anterior flap.

Amputation with imperfect flaps may often be the operation of choice. The higher the amputation, the greater the danger to life being the case, it will often be advisable to make a lower amputation than is consistent with a finished piece of work. A living patient with a poor stump is to be preferred to a dead patient with a nice stump. The surgeon is often justified in leaving a part of the wound uncovered rather than saw the bone higher. A granulating stump may later be covered with transplanted skin flaps. In the interest of the patient's life imperfect flaps may be advisable in the larger extremities. In the interest of later usefulness the phalanges may be left uncovered, and later treated by plastic operation. Every effort should always be made to preserve phalanges of the fingers. The line of amputation should not be determined so much by the possibilities of skin covering as by the vitality of the bone and the integrity of the joints and tendons. In the foot the distal end of the first metatarsal bone should be sacrificed only as a last resort.

Amputation without flaps is a method which should be used more than it is. Most amputations are operations of desperation. Commonly the nutrition of the soft tissues is poor. The nourishment of the tissues near the bone is better than that of the tissues near the skin. For this reason amputations of emergency for gangrene and sepsis best serve the immediate purpose when the operation ends with a conical stump. The customary method of making flaps requires usually the sacrifice of more bone than the emergency demands should be sacrificed. The sound bone is removed in order that flaps may be cut. Often these flaps are infected or poorly nourished and slough, and the bone is sacrificed for naught. In such cases the skin is in the most precarious condition. It is unwise to sacrifice the surest and most important structure, the bone, in the interest of the doubtful skin. Thus in such a condition as gas bacillus infection (gas gangrene), a circular or oblique amputation should be done without regard to saving flaps.

The skin should be cut, and then the muscle should be cut slowly, layer by layer, so that each layer retracts before the next is cut. The bone should be divided at the level of the last cut layer of muscle. The result is a slightly oval end, the bone being the longest, the muscle next, and the skin retracting furthest. But in the presence of infection and defective nourishment the advantages of such an amputation are incalculably great, compared with the old-fashioned flap amputation. Drainage is secured and the best conditions for nourishment are present.

After a few days, when the control of the infection is guaranteed, and the vitality of the parts assured, straps of adhesive plaster may be applied laterally and traction made as for fracture. This will in time convert the end of the stump from an oval shape to a funnel. Ultimately a short piece of bone may have to be cut off.

This is the rational emergency operation to be used in cases of infection and gangrene. In connection with the secondary operation, transplantation of fat, fascia, and skin may be made, from some other part. The covering of the end of the stump then becomes a matter not of emergency but of leisurely convenience. The only emergency in such cases should be met by the sacrificing of as little tissue as possible. When the life of the patient is the main question, the esthetics of the stump should be deferred—especially when it adds to the hazard and shortens the limb.

Flapless amputation is to be preferred in emergency amputations done on account of sepsis. The amputation is made as low as possible with the preservation of bone and muscle. This does not destroy the deep nourishment as do amputations with flaps; gangrene and extension of infection are less apt to occur; secondary hemorrhage is prevented; drainage is better; and the operation is more quickly done. The bone projects beyond the soft tissues. The later reamputation can be done at a time when danger has passed and no emergency exists.

Excess of bone may be removed later by making a longitudinal incision in the soft parts, detaching the tissues from the bone, passing a wire saw around it and cutting it off. Another method consists in making two punctures on the side of the limb farthest from the vessels. They should be separated by about one-third of the circumference of the limb. A clamp is passed into each opening and a wire saw drawn through. The bone may thus be divided with very little violence to the soft parts.

Amputations with Reference to Prosthetic Apparatus.—*Stumps for weight-bearing* are the aim in amputations of the lower extremities. Although the pressure of the modern artificial leg falls upon the bony tuberosities next above the amputation and upon the sides of the stump, still the end of the stump must bear some of the weight. The surgeon in operating should think of the apex of the stump as having the great importance. Scars should preferably be posteriorly because the front of the stump is used to throw forward the artificial limb. In stumps having less than one-third of the length of the shaft of the bone, every centimeter of length that can be preserved is important in furnishing leverage to swing the artificial limb. From this point toward the joint the length of the bone increases in importance in comparison to the covering; from this point downward the covering of the stump increases in relative importance to the length. In the foot as much of the bone should be saved as is possible, irrespective of lines of amputation.

Osteoplastic operations are to be preferred in amputations of the leg and thigh. These operations give a better bone-end, and are to be used whenever possible. The contra-indications are the necessity for haste and the

presence of infection. In the arm and forearm osteoplastic operations are of advantage in some cases (see below).

Osteoplastic Amputations.—The bone was formerly sawed through without reference to any special treatment of the bone-end, the periosteum and bone being divided at the same level. It was observed that bone thus treated degenerated by rarefaction and became pointed at its end. Later a flap of periosteum was used to cover the end of the bone; by which means the nourishment was improved and a better ultimate result believed to be secured. Still bones so treated are prone to be tender at the end and to show a tendency to conical atrophy. There is always a tendency in the

Fig. 1898.—Osteoplastic Amputations (First Stage).
Showing method of cutting bones.

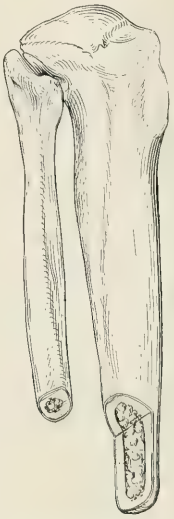


Fig. 1899.—Osteoplastic Amputation (Second Stage).
Showing bones cut.

periosteal covering to send out projections of bone which cause pain. The modern preference is to cover the bone-end with a flap of living bone.

This is now the operation of choice in amputations of the leg. Here a piece of bone is taken from the tibia in such a way that it may be bent across, connecting the two bones of the leg and covering their ends. A large anterior and a small posterior flap of skin and muscle are cut as usual and dissected back to a point below the saw line, far enough to leave still covered a length of tibia long enough for the transverse bridge. The tibia and fibula are sawed off at this point. The stump of the tibia is then sawed longitudinally in a plane parallel with the antero-internal surface which is to remain undivided (Fig. 1898). The fibula and the postero-external aspect of the tibia are sawed horizontally at the desired level. The tibia is sawed

as far as the end of the perpendicular saw cut (Fig. 1899). This leaves a projecting piece of tibia. The attachment of this piece to the overlying

FIG. 1900.—OSTEOPLASTIC AMPUTATION (THIRD STAGE).
Showing larger bone notched for breaking.

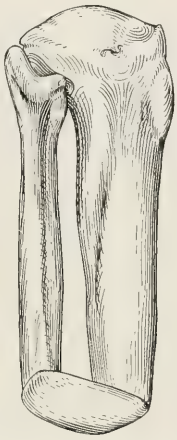


FIG. 1901.—OSTEOPLASTIC AMPUTATION (FOURTH STAGE).
Showing flap of bone connecting two bones and covering ends.

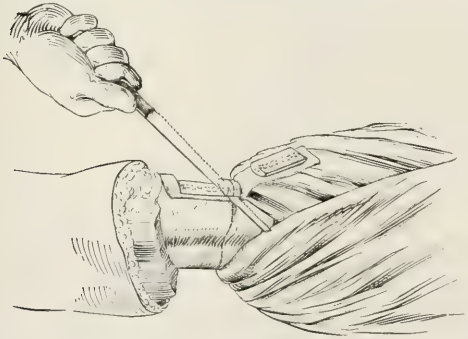


FIG. 1902.—OSTEOPLASTIC AMPUTATION.
Method of Kocher, showing bone flap cut with saw. The dotted line represents the line of circular incision.

soft parts should be carefully protected. A notch should then be cut with saw or forceps at the base of this piece on the raw side. This notch should

be as wide as the projecting piece is thick, and should be carried through the bone to the periosteum (Fig. 1900). It is best that a very thin shell of bone be left in order to be sure that the periosteum is not cut at the bottom of this notch. This flap of bone is then bent outward and backward and caused to rest upon the cut end of the fibula (Fig. 1901) to which it may be made fast by sutures of the soft parts or by drilling the bone. If some bone remains undivided at the bottom of the notch, it may be broken by bending the flap inward before turning it back in place.

This same principle of operating may be applied to the radius and ulna. Kocher performed this operation with the wire saw, first marking out a periosteal flap, elevating the periosteum a short distance, then cutting the bone flap, and turning it back before sawing through the two bones (Fig. 1902). In all of these steps it is most important that the attachment of the bone flap to the overlying soft parts be preserved.

FIG. 1903.—OSTEOPLASTIC METHOD OF BIER.

The end of the bone is covered with a bone graft which may be taken from elsewhere or represent a flap with its periosteum still connected.

In amputations through the *femur* and *humerus*, osteoplastic operations are done by some surgeons. The value of this method at these sites is not yet determined. The operation is similar to that done in the leg and forearm except that the bone flap is not so long. A flap of bone, attached to the overlying soft tissues, is cut as above described. It should have a length equal to the diameter of the bone. It should be cut with a periosteal flap surrounding it, and then turned back to cover the end of the bone (Fig. 1903). In the shaft of the femur and of the humerus a rounded piece must be used; but the shaft of the tibia furnishes a flat surface. Bier advocated making a separate osteoplastic operation for each bone of the leg just as is done in the thigh and upper arm.

Osteoplastic treatment of the amputated bone was developed by Bier and his associates about 1890 (Deutsche Zeitschr. f. Chir., xxxiv, 1892, 436). Binnie (Trans. Fourth International Surg. Congress, 1914), instead of turning in a plastic bone flap, transplanted a free piece of bone. All of these osteoplastic methods, it must be borne in mind, require an aseptic field, and are therefore not available in many traumatic cases.

It should furthermore be borne in mind that whatever is done to the end of the bone, both the bone and muscle are going to degenerate unless they are called upon to perform some function. The bone degenerates because weight can rarely be borne upon its end, and the muscle because its distal attachments are destroyed and it no longer has the power of contraction and expansion. The bone atrophies. The muscle becomes converted into connective tissue. It is for these reasons that the cinematic stump is always to be preferred, and the old-fashioned amputations which permit the muscle to decay and disappear are but poor makeshifts of surgery. If a cineplastic operation is not done the stump should be constructed to bear weight on its end. This means that especial consideration should be given to the padding of the end and to the location of the scar.

Tenoplastic amputations (cinematic or cineplastic amputations) have been applied especially in the arm, although they are applicable in the leg and in every other part where muscles move bones. The object is to preserve the

power of the tendons so that they may operate upon the prosthetic apparatus. This is one of the most fruitful fields of surgery, and remains yet to be more widely used. To cut off an arm, leaving the muscles of the stump nourished and supplied with motor impulses, and then fail to utilize this power, and allow it to waste away and the muscle to degenerate for want of use, will be looked back upon as one of the glaring deficiencies of ancient surgery. Already steps to remove this reproach are being taken in operations on the arm; and in the near future these methods will find general adoption.

To A. Ceci (Presse Médicale, xiv, 1906) and to G. Vanghetti (Presse Médicale, vol. xv, 1907) belongs the credit for bringing to recognition the possibilities of this work. As yet these methods are in a state of development; but their possibilities are very great. In cases of infection the cinematic procedure may be applied as a secondary operation. Tendon may be used for transmitting power by turning back its end and making a loop, by sewing it to other tendons, by making a knot of tendon or bone on the

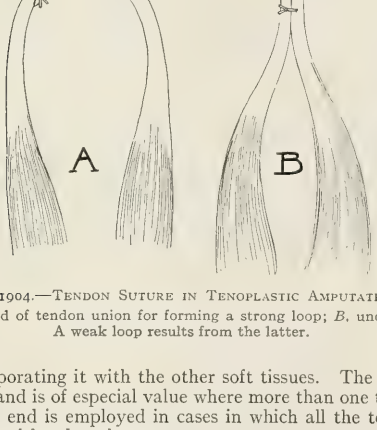


FIG. 1904.—TENDON SUTURE IN TENOPLASTIC AMPUTATION.
A, Preferred method of tendon union for forming a strong loop; *B*, undesirable method. A weak loop results from the latter.

end, or by incorporating it with the other soft tissues. The loop method is to be preferred, and is of especial value where more than one tendon group is used. The club end is employed in cases in which all the tendon ends are matted together with other tissues.

Cineplastic amputation through the forearm should if possible provide *double plastic motor stumps*. The posterior of these contains the extensor tendons, and the anterior the flexor tendons. The amputation is begun by making a circular incision through the skin and subcutaneous fascia as low in the forearm as possible. The muscles and tendons are divided down to the bone on a level with the retracted skin. Vertical radial and ulnar incisions are then made down to the bone extending about 15 cm. (6 inches) up the arm. The anterior and posterior flaps are then dissected up. Each of these flaps contains tendons, muscles and all of the other soft tissues between the skin and the bones. The bones are cut at the level of the upper end of the vertical incisions; that is, at the base of the flaps. One flap contains flexor

tendons and the other extensor tendons. The skin and fascia are then dissected free from each flap for about half the length of the flap. In each flap the tendons are divided into two groups, and these two groups of tendons are sewed together in such a way as to make a loop (Fig. 1904). The skin of each flap is then doubled upon the flap to cover the tendon bundles. As this is done a longitudinal button-hole is made in the skin at such a position that it comes opposite the tendon loop and a second button-hole is made in the part of the flap which is folded back. These button-holes should be about 2.5 cm. (1 inch) long. They should have fully 2.5 cm. of surface between them, and the distal one should be at least 2 cm. ($\frac{3}{4}$ inch) from the border of the skin. The doubled back skin flap is then sutured, skin edge to skin edge (Fig. 1905). The button-hole through the tendon loop is sutured in such a way that the skin of one side of the flap is sutured to the skin of the other side. All raw surfaces are thus covered. The same operation is done with each flap. It is advisable to use

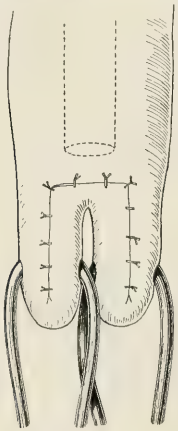


FIG. 1905.—CINEPLASTIC AMPUTATION. METHOD OF VANGHETTI.

Showing manner of construction of flaps to secure skin covering over the muscles. Rubber tubing is placed in the apertures through the flaps.

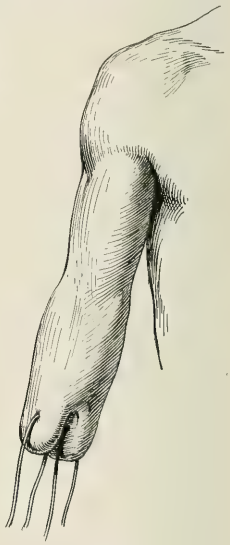


FIG. 1906.—CINEPLASTIC AMPUTATION.

Healed stump. Showing cords passing through apertures.

a small drain in the base of each flap to relieve tension. A piece of rubber tubing is placed through each button-hole, and as healing progresses more and more tension is put upon the tubing in order to prevent contraction of the muscles. This tension cannot be made strong earlier than the second week because of the danger of pulling apart the sutured surfaces; but slight tension can be employed after the second day. The tension should be applied only intermittently, as continuous tension is apt to cause necrosis or provoke pulling out of the button-hole. The tension is necessary to prevent degeneration of the muscle. Adhesive plaster traction should first be used.

After healing has been secured cords of rubber or other material are passed through the holes (Fig. 1906). The cord from the posterior flap is connected with the extensor apparatus of the fingers of the prosthesis, and the anterior is connected to the flexor apparatus. Patients with such an apparatus can open and close the fingers and grasp objects (Fig. 1907). The after-care of such a stump is very important. The skin must be kept healthy by daily bathing. Attention should be directed to the surfaces between the two flaps and to the holes for the cords to see that chafing does not develop. The cords and the prosthetic apparatus should be so adjusted that they may be relaxed at will and the pressure on the holes in the flaps released.

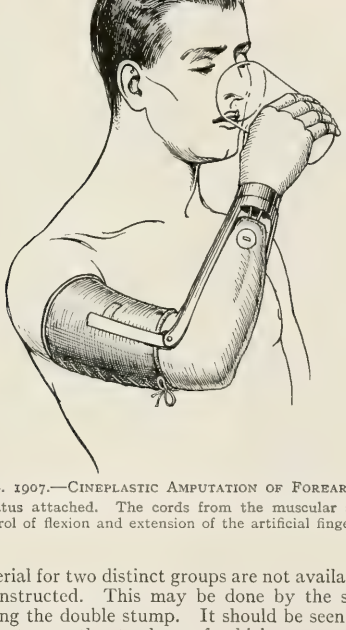


FIG. 1907.—CINEPLASTIC AMPUTATION OF FOREARM.

Prosthetic apparatus attached. The cords from the muscular stumps pass to the fingers and give control of flexion and extension of the artificial fingers. A large button holds the cords.

When the material for two distinct groups are not available, a *single motor stump* may be constructed. This may be done by the same principle as employed in making the double stump. It should be seen to that the muscles entering the stump, the tendons of which are preserved, have the same innervation. If any tendons representing two sources of nerve supply can be found, then a double and not a single stump should be made. This is entirely a matter of election. It is possible to unite all of the tendons, flexor and extensor, into one group, and get good function (Fig. 1907*a*). Vanghetti and DeFrancesco grouped extensors and flexors in one mass (Arch. für klin. Chir., 1908).

In making cineplastic amputations it is possible, especially in traumatic cases, to preserve much tendon. The ends of tendon, together with enough

skin to cover them, may often be saved from that part of the extremity which in the old form of amputation would be sacrificed. The surgeon is in no wise bound to adhere to typical methods of marking out flaps. He should get tendons and skin covering wherever they can be had. It is imperative that a good strong tendon loop with abundant accessory tissue be provided (Fig. 1907*b*).

Besides making a single motor stump with a button-hole for attaching the power transmission, a button or clubbed end may be made in such a way that it will retain a collar to which the power transmission may be attached. The amputation is done through the lower part of the arm. The skin and fascia

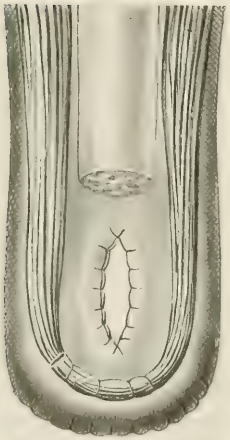


FIG. 1907*a*.—TENDON LOOP IN CINEPLASTIC AMPUTATION OF ARM.

This is the loop method of Ceci. A strong loop is formed by uniting the biceps and triceps.

FIG. 1907*b*.—DOUBLE MOTOR STUMP OF ARM.

This cineplastic stump shows a loop constructed from both the flexor and extensor muscles after the method of Sauerbruch.

are first divided by a circular incision. The tendons, muscles, and other structures are then cut down to the bone at a level with the upper border of the skin wound. Two lateral longitudinal incisions down to the bone are then made, and the flaps dissected up from the bone. These flaps may be about 10 cm. (4 inches) long. The bones are divided at the root of the flaps.

If a *motor loop* is to be made, the tendons of the flexor group are sewed to those of the motor group. The skin of each flap is then doubled longitudinally upon itself and caused to cover the loop.

A. P. C. Ashurst (Annals of Surg., vol. 60, 1914) worked out a valuable method of loop construction for the arm. Flaps are so marked out as to

provide skin for covering separately the triceps and biceps masses (Figs. 1908 and 1909). The triceps and biceps stumps, having been covered with skin, are united to form a loop (Fig. 1910). Instead of making a separate flap to cover the end of the bone a simple external and internal incision may be used, producing an anterior and a posterior flap which may be wrapped around the muscle and sewed (Fig. 1911).

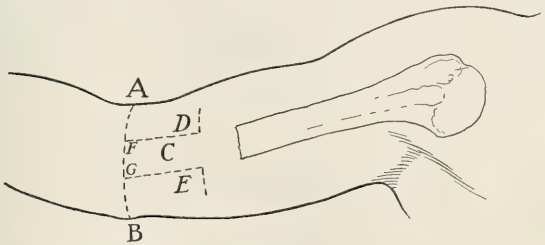


FIG. 1908.—CINEPLASTIC AMPUTATION OF ARM.

Inner aspect of arm. Showing flaps marked out for covering muscles. Circular amputation is done at *AB*. The flap *C* covers the end of the bone; *D* covers the biceps; and *E* covers the triceps. (Device of Ashurst.)

Immediately after cineplastic amputations extension must be made to prevent retraction of the muscles. This can not well be done by means of a cord through the stump orifice because it is apt to pull out. Extension is best made by means of adhesive plaster, which may be connected by elastic extension with a metallic crane (Fig. 1911*a*).

By using adhesive plaster in connection with a ring "spreader," pressure may be taken away from the wound and the dressing not interfered with by the traction apparatus (Fig. 1911*b*).

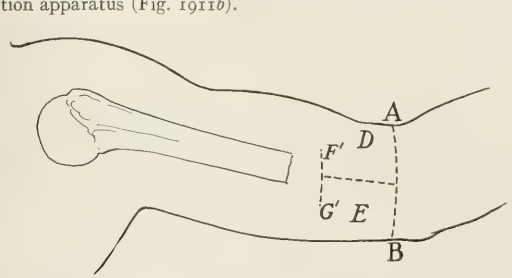


FIG. 1909.—CINEPLASTIC AMPUTATION OF ARM.

Outer aspect of arm. Showing manner of marking out flaps. The end of flap *FG* is sutured to *F'G'*. (Device of Ashurst.)

After operation, when the stump is healed and before the artificial hand is ready, the patient should use some simple device for preserving the function of the muscles. An ordinary splint with an extension piece to which a light elastic cord may be attached suffices (Fig. 1912).

If a *motor club* is to be constructed, in the forearm, the circular skin incision is carried out, and the longitudinal lateral incisions made. The

radius and ulna are exposed. The soft tissues are divided to the bone. Flaps of all soft parts are dissected up for a distance of about 2.5 or 4 cm. (1 or 1½ inches) and the tendons secured and sewed together over the sawed ends of the bone. Then through the lateral incisions a segment 2.5 cm. (1 inch) long of each bone is removed. This segment should be about 2 cm. (¾ inch) from the end of the bone. This leaves a fragment of radius and ulna 2 cm. (¾ inch) long in the flap. The lateral openings in the skin

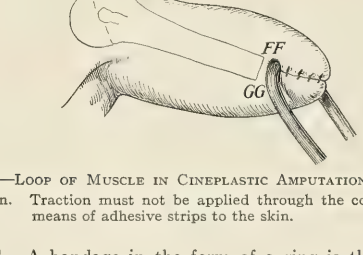


FIG. 1910.—LOOP OF MUSCLE IN CINEPLASTIC AMPUTATION OF ARM.
Completed operation. Traction must not be applied through the cord at first, but by means of adhesive strips to the skin.

are then sutured. A bandage in the form of a ring is thrown about the stump to make gentle pressure to keep the bone fragments from retracting upward. Gentle traction should be made on this during healing. The traction and pressure at first should be very gently made. After healing has been secured motion is transmitted to the prosthetic apparatus through cords attached to a hard rubber ring which sinks into the groove between the bones (Fig. 1913). The cords are carried to cords flexing the fingers of the appara-

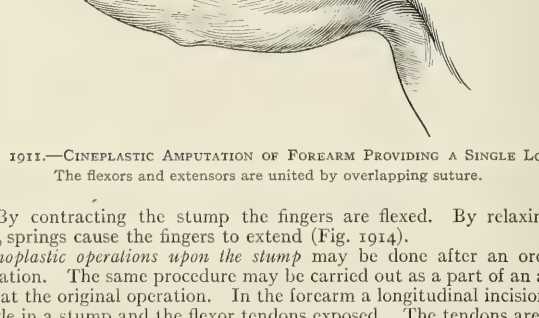


FIG. 1911.—CINEPLASTIC AMPUTATION OF FOREARM PROVIDING A SINGLE LOOP.
The flexors and extensors are united by overlapping suture.

tus. By contracting the stump the fingers are flexed. By relaxing the stump, springs cause the fingers to extend (Fig. 1914).

Tenoplastic operations upon the stump may be done after an ordinary amputation. The same procedure may be carried out as a part of an amputation at the original operation. In the forearm a longitudinal incision may be made in a stump and the flexor tendons exposed. The tendons are lifted forward in a mass from the bones. The superficial group is separated from

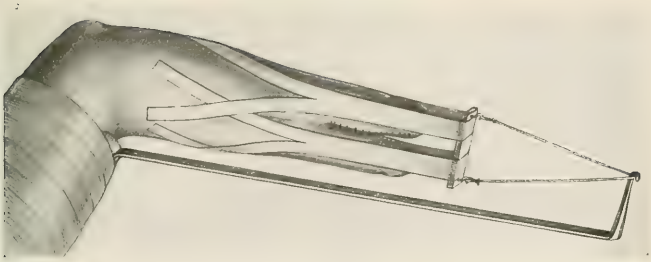


FIG. 1911*a*.—EXTENSION APPARATUS FOR CINEPLASTIC STUMP.

Adhesive plaster provides attachment for an elastic cord, which is connected to a metallic crane, bandaged to the limb. This is the traction that must be used while the wounds are healing.

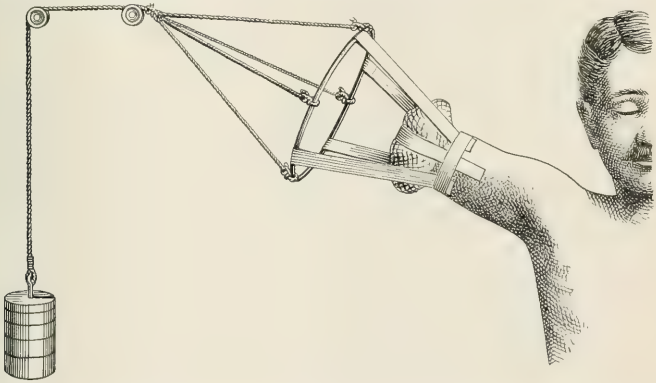


FIG. 1911*b*.—RING-TRACTION ON AMPUTATED STUMP.

The ring spreader takes the pressure of the traction away from the wound and permits changing of dressing without interference with the traction.

FIG. 1912.—DEVICE FOR PRESERVING FUNCTION OF THE MUSCLES PENDING CONSTRUCTION OF ARTIFICIAL HAND.

the deep group and the two groups sewed together as far forward as possible. There is an advantage in leaving the tendon ends still attached to the stump to prevent retraction. This tendon loop is then covered by a skin flap (Fig. 1915). Some further skin plastic may be required to heal the wound. After the wound is healed the end of the tendon group is freed and covered with skin. A hole is made in it to carry a cord to the prosthetic fingers.

In order to make a motile stump from a stump in which the tendons have been sewed over the ends of the amputated bones of the forearm, a series of operations may be done. The steps of such an operation carried out in my service by my associate, Carl Fulda, are shown. A longitudinal incision is made on the front of the forearm (Fig. 1916) and the tendons exposed.

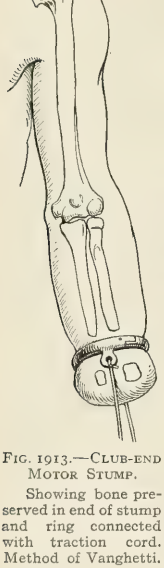


FIG. 1913.—CLUB-END MOTOR STUMP.

Showing bone preserved in end of stump and ring connected with traction cord. Method of Vanghetti.

A mass of flexor tendons is isolated but not detached from its insertion at the end of the stump. A flap of skin is dissected free from the dorsal aspect of the stump (Fig. 1917). The skin is sewed over the deeper muscles at the lower end of the wound, leaving exposed the flexor carpi radialis and the palmaris longus (Fig. 1918). The skin flap from the dorsal side is brought around and placed behind the isolated muscles (Fig. 1919), and then carried around them and sewed in such a manner as to form a complete skin envelope (Fig. 1920).

In these operations in which tendons are attached to the end of an amputation stump, the muscles should be kept potent by exercise. Although there is nothing for them to move, still by making the motions of flexing and extending imaginary joints, the muscles may be kept active. When the flexor and extensor tendons have been sewed together over the end of an amputated stump, it is surprising to see how these two groups may be kept strong and motile by alternate contractions. Gradually they loosen the tendons from their adhesions, and cause them to glide back and forth over the ends of the bones in response to the muscular contractions.

A plastic worked out by the author, consists in covering the loop with three skin flaps in such a way that the hole in the projecting tendon group is made at the same time that the tendons are covered with skin (Fig. 1921). The tendons of the flexor groups are lifted up through a long incision (*AB*) and isolated. The deep flexors are separated from the superficial flexors excepting for the lower 2.5 cm. (1 inch). If the tendon ends have previously been made fast to the end of the stump, they may be left attached there to prevent their retraction. A quadrangular skin flap is dissected up at (*C*). It is freed to within 1.5 or 2 cm. (½ or ¾ inch) of the edge of the wound. The free end of the flap is then passed under the deep flexor group of tendons and brought back again between the deep and the superficial groups, and sutured at its base. A flap twice the size is cut from the opposite side (*D*). This flap is divided into 2 parts, the cleft passing nearly to its base. The upper part of this flap is wrapped around the superficial flexor group opposite (*C*), and the lower part is wrapped around both the deep and superficial groups. The upper part of the longitudinal wound (*AB*) is closed over the roots of the tendons. A layer of

gauze is placed between the opposing skin surfaces. The wound under the lower skin flap is covered with rubber protective and gauze. The extreme lower end of the wound is left covered with protective but not sutured.

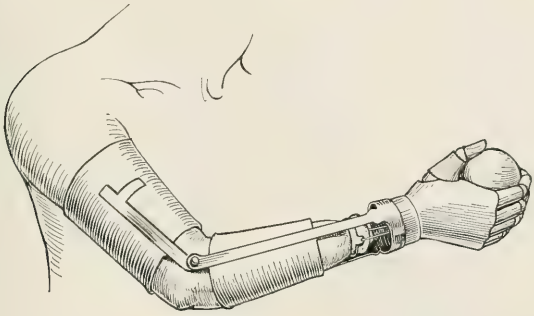


FIG. 1914.—CLUB-END MOTOR STUMP IN OPERATION.
The muscle pull flexes the fingers; extension of the fingers is accomplished by elastic springs.

After two weeks or longer, when the circulation in the skin flaps will warrant it, the flaps are cut free from their pedicles. Later the distal attachment of

FIG. 1915.

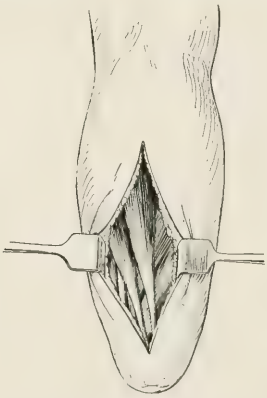


FIG. 1916.

FIG. 1915.—OPERATION ON STUMP TO COVER TENDONS WITH SKIN AND PRODUCE A CINEPLASTIC LOOP.
FIG. 1916.—ANTERIOR TENDONS EXPOSED IN STUMP OF FOREARM.

the tendons is cut. When this last operation is performed, the tendon mass, containing an eye for the prosthetic cord, and covered with skin except at its extreme end, is liberated. Downward traction should be begun

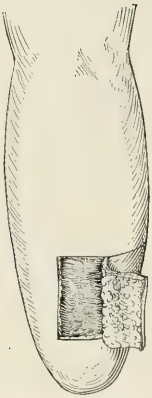


FIG. 1917.—DISSECTION OF SKIN FLAP FROM DORSUM OF STUMP OF FOREARM.

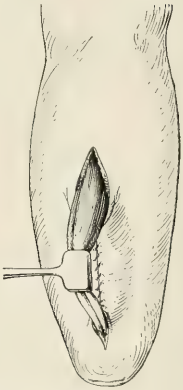


FIG. 1918.—SKIN SEWED UNDER SUPERFICIAL MUSCLES OF FOREARM STUMP AT LOWER PART OF WOUND.

FIG. 1919.—SKIN FLAP FROM BEHIND IS PLACED UNDER THE MUSCLES.

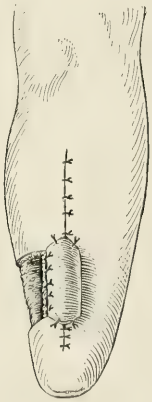


FIG. 1920.—SKIN FLAP SEWED AROUND MUSCLES.

at once to prevent retraction of the tendons. The resulting skin denudations in this operation may be covered by further skin plastic or by skin grafts.

The result sought is an isolated motor mass, capable of making voluntary contractions upon a prosthetic apparatus (Fig. 1922). In all other motor stumps the forearm must be flexed in order to operate the tendinous pull. In this operation the end of the stump itself serves as the resistance against which the prosthesis presses, and the tendons operate either with the elbow flexed or extended.

The same operation may be done upon the posterior aspect of the arm and the extensors brought into use through the same technic. As a pre-

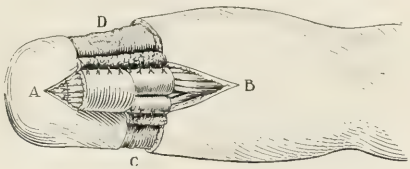


FIG. 1921.—AUTHOR'S METHOD OF COVERING THE TENDON MASS WITH SKIN.

liminary to such operations it is only necessary that an amputation in the forearm be done as low as possible and that the tendons of the flexor group be sewed over the ends of the bones to those of the extensor group. This same principle may be employed in the leg.

For securing an epithelial lining in the canal, Sauerbruch made a tube of skin and drew it through the musculotendinous opening (Fig. 1922*a*).

In all of these operations it is best that the united tendons which are to sustain the pull of the prosthetic cord should be united by transverse overlapping (Fig. 1904, *A*) if possible, in preference to lateral longitudinal

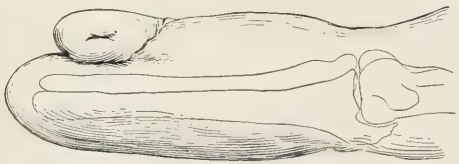


FIG. 1922.—RESULT AFTER TENDON MASS IS COVERED WITH SKIN.
From drawing of one of author's cases.

union (Fig. 1904, *B*). After any operation, a button with a single cord is to be preferred to a cord alone, as it causes less pressure damage.

Cineplastic amputation through the upper arm should, if possible, provide a *double motor stump*. This is secured by the same means as in the forearm. The biceps entering chiefly into the composition of the anterior stump and the triceps into the posterior. A *single motor stump* is made by sewing the biceps to the triceps in the stump below the bone-end. The skin covering for the loop is made as in the forearm; or after the stump is created a button-hole may be made and the skin sewed through the opening as in the forearm. Traction must be maintained carefully during healing. A cord through the opening is carried to the flexor apparatus of the fingers. When the stump is contracted the fingers are flexed and objects may be grasped (Fig. 1923). Springs extend the fingers when the muscular pull is relaxed.

In such amputations one group of muscles may act upon the elbow and the other on the hand. The muscles perform the flexor motions while springs perform the extensor motions.

Cineplastic amputations of the thigh and leg are carried out by the same principles as in the arm. By means of such operations it is possible to give motility and suppleness to the lower extremity. In the leg a motor stump

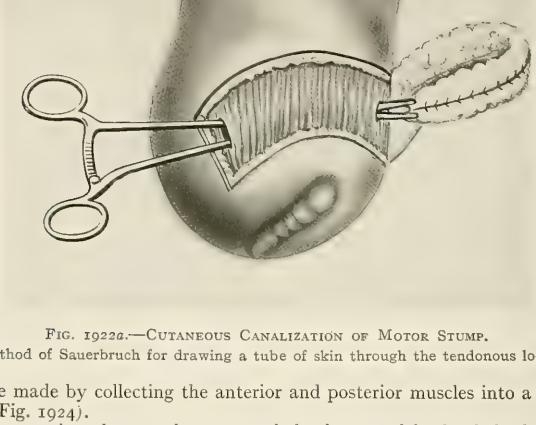


Fig. 1922a.—Cutaneous Canalization of Motor Stump.
Method of Sauerbruch for drawing a tube of skin through the tendonous loop.

may be made by collecting the anterior and posterior muscles into a motor mass (Fig. 1924).

For covering the muscle groups of the front and back of the leg skin may be taken from whatever area remains undestroyed. As an example, a long posterior flap of skin and a short anterior flap may be preserved

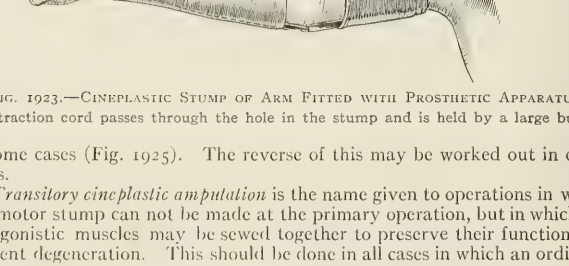


Fig. 1923.—Cineplastic Stump of Arm Fitted with Prosthetic Apparatus.
The traction cord passes through the hole in the stump and is held by a large button.

in some cases (Fig. 1925). The reverse of this may be worked out in other cases.

Transitory cineplastic amputation is the name given to operations in which the motor stump can not be made at the primary operation, but in which the antagonistic muscles may be sewed together to preserve their function and prevent degeneration. This should be done in all cases in which an ordinary

amputation must be done. The tendons or muscles of the opposite sides of the limb are sewed together over the end of the stump (Fig. 1904, *A*). In the forearm or leg the united tendons play across the interosseous ligament. Pellegrini made an osteoplastic notch in which the muscles might glide (Fig. 1925*a*). By connecting the flexor to the extensor muscles in this manner the muscle may continue to be active and strong. When the time comes to utilize them for moving a prosthetic part they are found well nourished and movable, and ready for the plastic operation.

For a valuable bibliography of cineplastic amputations see V. Gaudiani (Annals of Surgery, April, 1918, vol. 67, page 414).

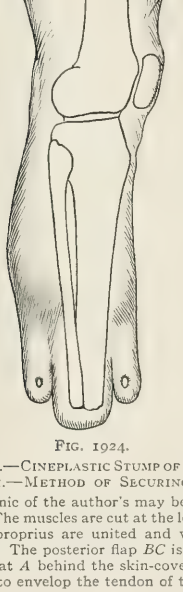


FIG. 1924.

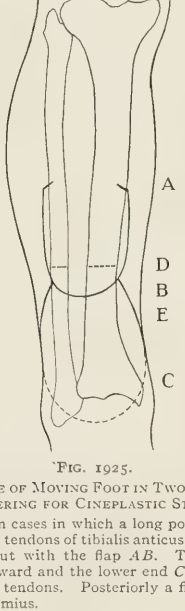


FIG. 1925.

FIG. 1924.—CINEPLASTIC STUMP OF LEG CAPABLE OF MOVING FOOT IN TWO DIRECTIONS.
FIG. 1925.—METHOD OF SECURING SKIN COVERING FOR CINEPLASTIC STUMP OF LEG.

This technic of the author's may be employed in cases in which a long posterior flap is available. The muscles are cut at the level *E*. The tendons of tibialis anticus and extensor longus and proprius are united and wrapped about with the flap *AB*. The bones are sawed at *D*. The posterior flap *BC* is brought forward and the lower end *C* is carried up and sutured at *A* behind the skin-covered anterior tendons. Posteriorly a flap similar to *AB* is made to envelop the tendon of the gastrocnemius.

For prosthetic apparatus for use in connection with cineplastic amputations, see Artificial Limbs, page 607.

Amputation with tendinous bone covering has two special advantages; (1) the bone end is covered, and (2) the muscles are preserved for future usefulness by the preventing of complete retraction. The operation begins as the ordinary amputation. The bone and periosteum are sawed across without plastic attention. Periosteoplastic or osteoplastic operation may be done if the surgeon desires; they are not necessary. All of the tendons

that are available are picked up and sewed over the end of the bone. If tendons on only one side can be used, then the ends of such tendons are carried across the cut end of the bone and sewed to the periosteal tissues on the other side. Additional lateral sutures may be required to prevent the tendons rolling off of the end of the bone. What is most desirable is that the flexor tendons on one side should be sewed over the end of the bone to the extensor tendons of the other side. When this is done two important things, beside covering the bone, are accomplished; (1) the tendons are fixed so that at a later operation they may be picked up and brought out in a tendoplastic operation on the stump (page 535), and (2) the two antagonistic groups of muscles still have their antagonism maintained and may thus be preserved from atrophy and degeneration. If a later plastic is not done to lift the tendons away from the bone-end, a pulley-like function may be developed and the flexor and extensor groups may by alternate action cause the tendons to slide back and forth across the end of the stump. This is facilitated if the sawed bone has been covered with fascia, other soft tissue, or by bone plastic. Atrophy and degeneration of the muscles are thus prevented, and the tendons are always available for the making of a tendoplastic motor stump at any later time.

FIG. 1925*a*.—TRANSITORY CINEPLASTIC AMPUTATION OF FOREARM.

Procedure of Pellegrini for preserving function of flexor and extensor muscles preparatory to formation of motor stump.

The After-treatment of the Weight-bearing Stump.—Ordinarily a stump, after the old-fashioned typical amputation, degenerates very rapidly, and becomes soft, flabby and tender. This should be prevented as far as possible by the character of the amputation. Whatever the operation much can still be done. Aseptic healing should be secured if possible. As soon as the wound is healed, the stump should be given massage twice daily with olive oil. The skin should be washed with warm water once a day and then treated with boric acid solution. The stump should lie on a soft padding.

It should be put to use as soon as possible. While the patient is still in bed a box should be so arranged that the patient can press the end of the stump against it. This should be done at first for a few minutes once a day, then twice daily, then oftener, until the patient can press the stump against a resisting surface for five or ten minutes every hour.

Along with the massage and pressure-treatment should go passive motion of the joint above the stump. Passive motion should be practised at each treatment. Later the patient should practise energetic active motion of the joints above the stump. Following this should come standing exercises. A bag of bran placed on a chair or other surface should be used to receive the weight of the body. The end of the stump should be placed on this, and gradually more and more of the weight of the body borne upon it. By the end of two or three weeks the patient should be able, after an aseptic

operation, to bear the weight of the body on the stump. Then a peg-leg (Fig. 1926) should be worn until permanent prosthetic apparatus is ready. Such peg-legs may be bandaged to the stump in the usual dressing and may be with or without end-bearing support (Fig. 1927). It is desirable that end-bearing should be begun early and kept up. The permanent prosthesis should provide for end-bearing. Above all the operation should have been done with this in view.

Comments on Weight-bearing Stumps.—In securing bearing surfaces results have not been as good as they have promised. At whatever point the

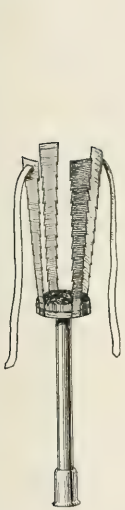


FIG. 1926.

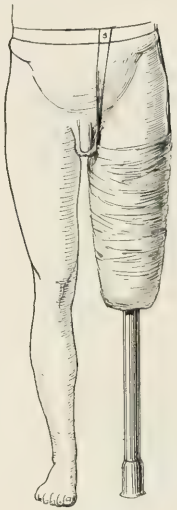


FIG. 1926a.

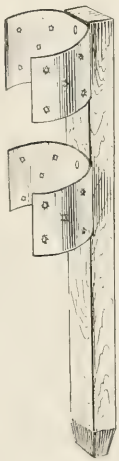


FIG. 1927.

FIG. 1926.—PROVISIONAL PEG LEG TO BE USED AS SOON AS POSSIBLE AFTER AMPUTATION. Modified from Jour. of A. M. A.

FIG. 1926a.—PROVISIONAL PEG LEG APPLIED TO RECENT STUMP. Modified from Jour. of A. M. A.

FIG. 1927.—PROVISIONAL PEG LEG WITHOUT END-BEARING REST. Modified from Jour. of A. M. A.

pressure of the prosthetic apparatus has been planned to fall, a stump which will not take pressure upon its end is not a successful stump. End-bearing is the test of the stump. The old methods of amputation through the shafts of the bones have been notoriously defective in furnishing weight-bearing stumps. The muscles degenerate and shrink into fibrous masses; the stump becomes small and pointed; and the end, about the bone, becomes tender and painful. This is the common tendency. An examination of ninety-six cases of amputation through the diaphysis of the thigh and leg showed only two that could bear direct weight upon the stump. Seventy of the stumps were distinctly bad.

In disarticulations and in amputations with a club surface, such as is

furnished by the articular end of a bone, a satisfactory bearing surface may be secured. Thus in the old amputations at the ankle, in which os calcis is turned up in the posterior flap and attached to the ends of the bone, and in the old thigh amputations, in which the patella is placed against the cut end of the femur, good bearing stumps have been secured. It was in response to these good results that the osteoplastic operations were invented and found to give results very superior to the simple diaphyseal amputation.

The use of periosteal flaps is so prone to be followed by painful exostoses, that its value is questionable. Many surgeons are rejecting it entirely. If infection has been present painful exostosis may be expected. Osteoplastic treatment of the end of the bone gives the best results, but can not be used in the presence of infection. Its results are so superior that in cases with infection, it will often be worth while to do an incomplete amputation, and when the infection has subsided do the osteoplastic operation.

Next in preference to the osteoplastic operation, the aperiosteal operation has the most to offer. It leaves a ring of diaphysis, without periosteum or marrow, to cap the bone. This slowly degenerates and becomes rounded away, protects the bone, and the throwing out of exostoses is prevented. It may be employed in the presence of complications which contraindicate closure of the wound.

The resulting stump depends upon many factors. Wherever possible, flaps should be taken which contain the toughest skin for end-bearing purposes. The treatment of the end of the bone in such a way as to prevent the throwing out of exostoses and the covering of the ends of the bone with a thick pad of soft tissue are most important. The maintenance of the vitality and activity of the muscles by giving them some function to perform is the factor for success which has been introduced by the newer methods. Finally the planning of the operation with the aim of securing a weight-bearing stump, the after-treatment to serve this object, and the early use of the stump in weight-bearing, are all most necessary for the securing of the best results.

AMPUTATIONS OF THE UPPER EXTREMITIES

Position.—In amputations below the elbow, a small table or rest should be placed at the side of the operating table, and the forearm should rest upon this. The patient should lie on his back. The hand should lie pronated when dorsal incisions are made and supinated when palmar incisions are made.

Anatomy.—For Bones of Hand, see Fig. 1928. For Vessels of Hand see Vol. I, page 427; of Forearm, Vol. I, page 421; and of Upper Arm, Vol. I, pages 418 and 415. For Joints see Vol. I, page 737. For Tendon Sheaths of Hand, see page 447. Further descriptions of bones will be found under Fractures, Operations on Bones and Joints, and Dislocations.

Amputation of Fingers.—The distal ends of the metacarpal bones and of the phalanges form the knuckles. The plane of the joints is, therefore, distal to the knuckles. In order to cut into a metacarpophalangeal or a phalangeal joint on its dorsal aspect when the joint is flexed at a right angle, the incision must be made fully a distance the thickness of the bone below the most prominent point of the knuckle. In other words, it should be remembered that the distal end of the proximal bone is the fixed point and the distal bone rotates around it. The margins of the webs of the fingers are about 2 cm. (¾ inch) below the joints.

In the fingers, the superficial flexor is inserted into the sides of the middle phalanges, the tendon being split for the passage of the deep flexor; the deep

flexor is inserted into the base of the last phalanx; the common extensor is inserted into the back of the last two phalanges. In the thumb, the short thumb muscles are inserted into the first phalanx; the long flexor is inserted into the last phalanx; the two long extensors are inserted respectively into the bases of the first and of the second phalanges.

In all amputations of the fingers as much tissue as is possible should be saved. No matter how short a stump is, it is of use. This is especially true of the thumb and index-finger. A short stump in one of the two middle fingers is of value to a man doing heavy manual labor, but in the case of a person who does not do heavy manual labor it may be removed for cosmetic

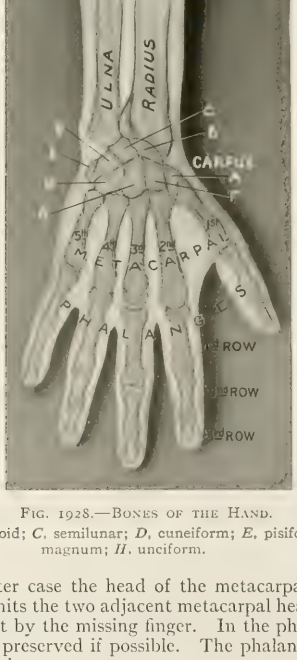


FIG. 1928.—BONES OF THE HAND.

A, Trapezium; *B*, scaphoid; *C*, semilunar; *D*, cuneiform; *E*, pisiform; *F*, trapezoid; *G*, os magnum; *H*, unciform.

reasons. In the latter case the head of the metacarpal bone may also be removed. This permits the two adjacent metacarpal heads to come together and close the gap left by the missing finger. In the phalanges the heads of the bones should be preserved if possible. The phalanx is much more efficient if the head remains.

The scars of operation had better lie on the dorsal surfaces. It is least desirable that they should be on the palmar surfaces. When there is not enough skin to cover the bone, especially in the thumb and index-finger, plastic flaps or grafted flaps may be used. Every expedient should be resorted to to make the important fingers long. When there is more flap than is needed to cover a shortened phalanx, rather than sacrifice the skin, bone

should be transplanted from elsewhere to lengthen the phalanx. Where tendons which move the phalanges have been cut haste should not be too great in sacrificing the phalanges; often the tendons may be sutured back in place. The tendons in the fingers should not be allowed to retract from an amputated phalanx, they should be sutured to the phalanx or to its tendon sheath and thus mobility of the terminal joint of the stump retained.

In amputating the thumb or little finger it should be borne in mind that the flexor tendon sheaths communicate with the great palmar synovial sacs which extend up under the annular ligament of the wrist, and that infection is a serious matter. The opening into this sheath should be closed by sutures. Where a part of the index- or little finger is saved, the flexor tendons should be attached to the sheath and periosteum by a few sutures and at the same time the sheath opening closed. If amputation is done at the first interphalangeal joint or higher in any of the fingers the deep and superficial flexor tendons are divided. Beyond the middle of the middle phalanx there is but one tendon on either side—the deep. Where the tendon sheath has been destroyed tendons may be sutured to periosteum, capsular ligament, or other tissues connected with the bone, or to the tissues of the flap. The action of the tendons upon the bones should not be lost.

For covering the end of a finger stump, skin from the palmar side is to be preferred. In amputating below the metacarpophalangeal joint a long palmar and a short dorsal flap are to be preferred. Next in preference is a long palmar flap. The scar is thus made to fall on the dorsal aspect of the stump. Whether one or two flaps are used, the transverse dorsal incision should have a downward convexity. The object of this is to make a rounded end to the stump. Flaps should be cut broad. The heads of the bones are large and if the flaps are narrow, it will be found that they are inadequate.

In cutting flaps a narrow scalpel should be used. The joints should be flexed when cutting dorsal flaps and extended when cutting palmar flaps. Bone should be cut with a fine sharp saw in preference to forceps. In disarticulations the capsular ligament should, as much as possible, be left with the proximal phalanx to serve as a part of the end covering of the bone.

Disarticulation is best done through the back of the joint. After marking out the skin flaps, the joint should be flexed and incised transversely. The extensor tendon is first cut. The knife then should follow close to the base of the distal phalanx and divide the lateral attachments of the capsular ligament and then the flexor tendons. The deep flexor tendon is divided in all disarticulations.

Both flexor and extensor tendons should be cut long enough to allow that they may be reattached. Thus in disarticulations of the last phalanx, the deep flexor should be sutured to the last phalanx of the stump, being attached preferably to its own tendon sheath, with a normal degree of tension. In disarticulation of the two distal phalanges, both flexor tendons are divided. These should be sewed to the front of the remaining phalanx, and the extensor tendon should be sewed to the dorsum. To determine the degree of tension, the tendons should be divided when the finger is straight, and the tendons sutured fast in just that position.

Finger amputations can be done well with local anesthesia. For tendon suturing fine chromic catgut is used. For buried sutures catgut, and for the skin sutures silk are employed. Drainage is to be used only in cases known to be grossly infected. A splint should be incorporated in the dressing to immobilize the wrist and the joints immediately above the amputation.

Special Amputations.—Here following are described briefly the special amputations. For the details, technic, and general principles of these operations see above.

Amputation through last phalanx is best done by a single palmar flap. The presence of the nail on the dorsum makes this necessary (Fig. 1929, *A*). The incisions outlining the flaps are carried to the bone; and the bone dissected free as far back as the saw line. The denuded bone must be held with forceps while it is cut with a fine saw. The palmar digital artery on each side requires to be ligated. The flap is sutured with fine thread.

Disarticulation of last phalanx is done with a *palmar flap*, the incision of the soft parts being slightly higher than in amputation through the phalanx. The dorsal incision should curve slightly downward (Fig. 1929, *A*). After division of tendons and disarticulation, the deep flexor tendon should be sutured to tissues of stump phalanx. The two lateral palmar digital arteries require ligation. The flap is sutured with fine thread.

The same operation may be done by *short dorsal* and *long palmar flaps* (Fig. 1929, *B*). The palmar flap should be a little longer than the diameter of the finger at the joint. The base of the flaps should be at the joint line. The

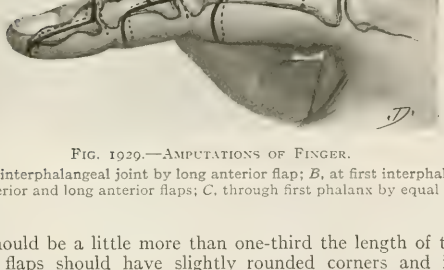


FIG. 1929.—AMPUTATIONS OF FINGER.

A, At lower interphalangeal joint by long anterior flap; *B*, at first interphalangeal joint by a short posterior and long anterior flaps; *C*, through first phalanx by equal anterior and posterior flaps.

dorsal flap should be a little more than one-third the length of the palmar flap. These flaps should have slightly rounded corners and include all the soft tissues down to the bone, excepting the retractile tendons. The flaps should be dissected back to the line of disarticulation. The capsular ligament should be left attached to the flaps and to the head of the remaining bone.

Amputation through second phalanx may best be done with (1) *long palmar flap* or (2) *short dorsal* and *long palmar flaps* (Fig. 1929, *B*).

By the first method, the flap should have its base at the saw line. The base should represent half of the circumference of the finger. The flap should have parallel sides; the end and corners should be slightly rounded; it should have a length equal to $1\frac{1}{2}$ times the diameter of the finger at the saw line. The dorsal incision should connect the two upper ends of the lateral incisions marking out the palmar flap. It passes across the dorsum of the finger, curving slightly downward. The incisions should penetrate to the bone, the flaps should be dissected back to the saw line, and the bone divided. The two palmar digital arteries require to be ligated. The deep flexor tendon should be caught and sutured in the sheath composed

of the enveloping superficial tendon. The flap should be sutured with thread.

By the two-flap method the flaps are made as for amputation of the last phalanx (see above). The lengths of the flaps vary with the size of the finger. The other steps of the operation are the same as for the one-flap procedure.

Disarticulation at first interphalangeal joint is done the same as disarticulation at the last interphalangeal joint. Either a single palmar flap or short dorsal and long palmar flaps may be used (see above).

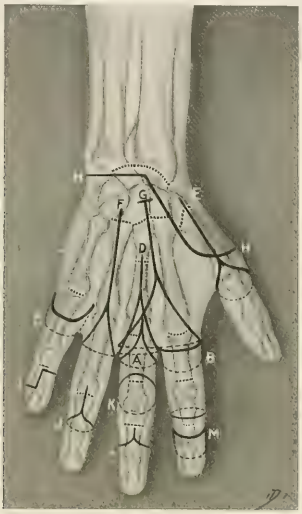


FIG. 1930.—AMPUTATIONS OF FINGERS, HAND, AND WRIST.

A, Oval method of disarticulation at metacarpophalangeal joint; *B*, disarticulation of index finger at metacarpophalangeal joint by palmar and dorsal flaps; *C*, disarticulation of little finger at metacarpophalangeal joint by palmar and dorsal flaps; *D*, amputation of third metacarpal bone with finger; *E*, disarticulation of first metacarpal bone with thumb; *F*, disarticulation of fourth metacarpal bone with finger; *G*, disarticulation of second and third metacarpal bones with their fingers; *H*, disarticulation of wrist-joint with lateral flap; *I*, *J*, *K*, *L*, *M*, various amputations and disarticulations of phalanges.

Amputation through first phalanx is done the same as through the second phalanx. Either a single palmar flap or a short dorsal flap may be used (see above).

Disarticulation of fingers at metacarpophalangeal joint is preferably done by the oval method (Fig. 1930, *A*). The vertical arm of the incision begins just above the head of the metacarpal bone. It passes downward across the middle of the knuckle to a little beyond the base of the first phalanx at a point midway between the base of the first phalanx and the edge of the web. This is with the joint flexed. The incision then diverges as a Y. The two

arms pass obliquely downward and backward, joining in a palmar transverse incision on a line with the free border of the web. The palmar incision is made with the fingers extended. This incision is best made with two strokes of the knife.

The flap incision passes first through skin and fascia. The incision is carried to the bone on a level with the retracted skin flap. The soft parts are retracted and the extensor tendon cut. The capsular ligament is cut close to the phalanx on each side. The flexor tendons are cut and the disarticulation completed. The two digital arteries are tied. The sheath of the flexor tendons is closed by suture. The wound is closed by suturing

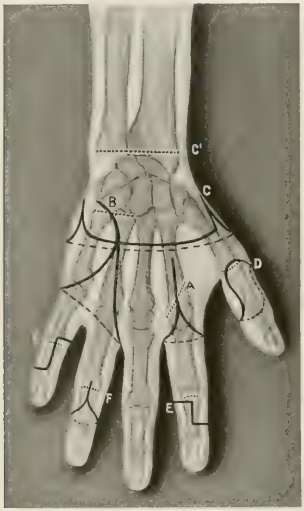


FIG. 1931.—AMPUTATIONS IN THE HAND AND WRIST.

A, Amputation of part of second metacarpal with index finger; *B*, disarticulation of last two metacarpal bones and fingers; *C*, *C'*, amputation at wrist joint by equal anterior and posterior flaps; *D*, disarticulation at metacarpophalangeal joint of thumb by long palmar flap; *E*, *F*, *G*, various disarticulations of phalanges.

the edges together in an anteroposterior direction in continuation with the line of the vertical arm of the incision.

If the incision has been carried too low a projection at the palmar end will appear as the incision is closed. In such an event this projection may be removed by a palmar Y incision, thus virtually converting the operation into one with two lateral flaps.

If a smaller symmetrical hand is desired in preference to a strong hand, the head of the metacarpal bone is removed. If this is to be done the vertical incision is prolonged upward to the middle of the bone, and the soft parts separated. The bone is isolated and amputated at the junction of the lower and middle thirds of the shaft in the case of the third or fourth metacar-

pal bones. In the case of the metacarpals of the index- or little finger, the head of the bone should be cut off obliquely, leaving the lower end longer on the side articulating with the adjacent metacarpal (Fig. 1931, *A*). In the latter case also the edge of the flap farthest from the palm may require to be shortened. The hand is weakened by operations removing the metacarpal head.

Amputations of Thumb.—Amputations and disarticulations of phalanges are done the same as in the fingers (see above).

Disarticulation of the thumb at metacarpophalangeal joint should be done in such a way as to preserve the mobility of the first metacarpal bone and insure ample covering for its head. It is best done by a *long palmar flap.* The base of the flap should be at the head of the metacarpal bone; the two

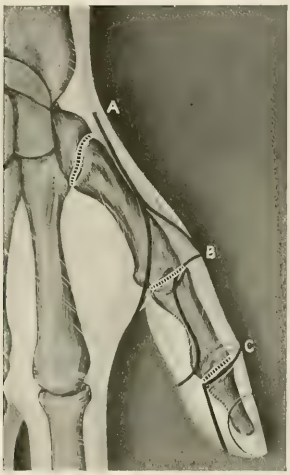


FIG. 1932.—AMPUTATIONS IN THE THUMB.

A, Disarticulation of first metacarpal bone and thumb by the oval method; *B*, disarticulation of thumb at metacarpophalangeal joint by long palmar flap; *C*, disarticulation of last phalanx by palmar flap.

lateral incisions should be in the midlateral line of the thumb; the end of the flap should be opposite the base of the last phalanx. This incision should differ from that used in the fingers in that the transverse lines of incision should be curved—the upper incision having its convexity upward and the lower having its convexity downward (Fig. 1932, *B*). The incision is deepened to the bone following the upper line of the retracted skin. Tendons are out in this line. The joint is opened posteriorly and the capsular ligaments divided. The sesamoid bones, which are connected with the flexor surface of the base of the first phalanx, should be separated from the bone and left attached to the flap. The dorsales pollicis arteries and the two branches of the princeps pollicis require to be tied. The small thumb muscles and the long tendons should be sutured to the remains of the capsular

ligament in the stump. This helps to strengthen the stump and maintain the mobility of the metacarpal bone. The synovial sheath of the flexor tendon should be closed with a fine catgut suture. The convex end of the palmar flap is then turned back and sutured into the concavity of the upper transverse incision. This covers the end of the bone with palmar tissue and places the scar out of the way of pressure.

By the *oval method* a longitudinal incision is begun on the dorsum of the thumb over the middle of the metacarpal bone. It passes downward to the base of the first phalanx where it divides as a Y. Each limb passes obliquely downward about the first phalanx to meet on the palmar aspect of the thumb opposite the middle of the first phalanx (Fig. 1933). The incision should be deepened to the bone in line with the upper limit of the

FIG. 1933.—OVAL METHOD OF AMPUTATION AT METATARSOPHALANGEAL JOINT.

retracted skin. Muscles and tendons are cut. The sesamoid bones are preserved in the flap. The short muscles and the long tendons should be sutured to the capsular ligaments which should be left attached to the stump. The vessels are ligated and the synovial sheath closed. The wound may be sutured in a straight line continuous with the vertical part of the incision; or the vertical incision may be closed, the lower limit of the flap turned back, and the wound sutured in the form of a Y.

Disarticulation of index-finger at metacarpophalangeal joint is best done by a *palmar and dorsal flap* operation. The latter may be slightly shorter than the former. The incision for cutting the palmar flap begins just behind the web at the highest point in the midlateral line between the index- and middle finger. It passes downward and forward, curving across the middle of the first phalanx, and thence upward in the midlateral line on the radial aspect as far as the joint. The dorsal incision begins at the first, passes transversely across the back of the first phalanx a little above its middle

and then curves upward to join the radial arm of the first incision (Fig. 1930, *B*). As the skin retracts, this incision is deepened to the bone. The joint is disarticulated, leaving as much as possible of the capsular ligament attached to the metacarpal bone. The digital arteries should be tied and the flexor sheath closed. The operation may be done by an *externopalmar flap.*

If the head of the metacarpal bone is to be removed the same flaps are made excepting that they are beveled or shortened on their radial side, and the bone is cut obliquely upward and outward (Fig. 1931, *A*).

Disarticulation of little finger at metacarpophalangeal joint is done by a *palmar and dorsal flap* operation. It is the same operation as for the index-finger. The palmar flap should be a little longer than the dorsal flap. The palmar incision begins just behind the web at the highest point in the mid-lateral line between the two last fingers. It passes downward and forward, curving across the middle of the first phalanx of the little finger, and thence upward in the midlateral line on the ulnar aspect as far as the metacarpo-phalangeal joint. The dorsal incision begins at the first, passes transversely across the back of the first phalanx a little above its middle and then curves upward to join the ulnar arm of the first incision (Fig. 1930, *C*). As the skin retracts the incision is deepened to the bone. The joint is disarticulated, leaving as much as possible of the capsular ligament attached to the metacarpal bone. The digital arteries should be tied and the flexor sheath closed. The operation may be done by an *internopalmar flap.*

If the head of the metacarpal bone is to be removed, the same flaps are made excepting that they are beveled or shortened on their ulnar side, and the bone is cut obliquely upward and inward as in the index-finger (Fig. 1931, *A*).

Amputations of the Hand.—For *anatomy* of tendons and bursal sacs, see Infections of Hand, page 447. (For vessels, see Palmar Arch, Vol. I, pages 426 and 427.) Prominences of the palmar aspect are formed by the pisiform bone, the scaphoid and trapezium. The edge of the webs between the fingers is about 2 cm. ($\frac{3}{4}$ inch) below the metacarpophalangeal joint. The superficial palmar arch is on a level with the lower border of the thumb when extended at a right angle to the hand. It lies across the metacarpal bones just above their middle, beginning on the outer side of the pisiform bone. The deep palmar arch crosses the second, third and fourth metacarpal bones near their bases.

In amputations the metacarpal bones should be saved whenever possible, as they contribute much to the strength of the hand. The head of the bone is most important. When the head of the first or fifth metacarpal can not be saved, the amputation should bevel the bone so as not to leave a square end of shaft. All bones of the hand, as in the fingers, should be cut with a thin sharp saw, chisel or wire saw. Cutting forceps should not be used as they crush and splinter the bone.

The carpal articulation of the first and fifth metacarpal bones commonly have independent synovial sacs, and disarticulation in infected cases may be done; but the synovial sacs of the second, third and fourth communicate with the large common carpal sac, and, in infected cases, the base of the bones should be left whenever possible in order to avoid opening the large sac. Where synovial sacs are opened in the presence of infection, free drainage should be provided. When infection is not present the sac should be closed by suture.

In amputations in the hand, wounding of the palmar arches or branches of the radical artery must be guarded against. The seriousness of infection of the synovial tracts should be kept in mind. Where antagonistic tendons

are divided, they should be cut long enough to allow sewing their ends together over the end of the bone or sewing their ends into the flap in order to secure their action upon the stump.

In disease or injury which requires removal of the whole or part of a metacarpal bone, it is not always necessary to perform amputation and sacrifice a finger. Often a simple resection of bone is required and this may be followed by inserting a transplant of bone to give support to the finger. In the hand as elsewhere amputation must always be regarded as a last resort and as a confession of defeat. (See Osteoplastic Operations, Vol. I, pages 710 and 772.)

Amputation of metacarpal bone with finger is done by the racket incision. The incision begins on the back of the hand a short distance above the point at which the bone is to be divided. The incision passes downward upon the metacarpal bone, and divides just above the head, one arm passing to the web on one side and the other passing to the web on the other side, and thence curving across the palmar aspect a little below the level of the free edge of the web, the two incisions come together (Fig. 1930, *D*). This is the same incision as used in metacarpophalangeal disarticulation, except that it is carried higher.

As the skin retracts the incision is deepened to the bone. The wound is retracted and the extensor tendons divided. The flexor tendons are divided at the neck of the metacarpal bone. The ligaments connecting the head of the bone with the adjacent metacarpals are divided. The bone is cut through at the desired level with a wire saw. The sheath of the flexor tendon is closed, the digital arteries tied, and the incision sutured as a longitudinal, dorsal, linear wound.

Amputation of first metacarpal bone with thumb is the same as for other metacarpal bones (see above). The racket incision extends higher than for disarticulation of the first metacarpophalangeal joint, and not so high as for removal of the whole of the first metacarpal bone (Fig. 1930, *E*). The metacarpal bone should not be sawed transversely but should be beveled from below upward and outward. For disarticulation, the whole operation is done higher.

Amputation of fifth metacarpal bone with little finger is the same as for amputation of other metacarpal bones (see above). The racket incision extends higher than for disarticulation of the fifth metacarpophalangeal joint, and not so high as for removal of the whole of the fifth metacarpal bone. The metacarpal bone should not be sawed transversely but should be beveled from below upward and inward.

Amputation of fourth and fifth metacarpal bones with their fingers is done by the same incisions as disarticulation of the entire metacarpal bones with their fingers excepting that the incision is not carried so high (see below). The operation may be done by the *racket incision*, the vertical arm of the racket lying on the back of the hand between the two bones and ending above at the saw line; or it may be done by *double flaps*—a dorsal flap and a slightly longer palmar flap. In either operation the ulnar side of the flap should be shorter than the radial side.

Amputation of three inner metacarpal bones with their fingers is done by the same incisions as the above. When the *racket* method is employed the vertical arm of the incision lies on the dorsum of the fourth metacarpal, and extends as high as the saw line. When the *double flaps* are used, the palmar flap should be the longer and the flaps should be shorter on their ulnar side.

Amputation of the four inner metacarpal bones with their fingers is done

by a *palmar flap* as for disarticulation of the entire bones (see below). It is only a question of the level of the operation.

Disarticulation of metacarpal bones with fingers is done by the *racket* method in the case of individual metacarpals and for removal together of third and fourth metacarpals, and of the fourth and fifth. *Double flaps*—dorsal and palmar—are best for the three and four inner metacarpals, the palmar flap being somewhat longer than the dorsal. A *palmar flap* operation is best for removal of the inner four metacarpals or for removal of all of the metacarpals.

When all of the metacarpal bones must be sacrificed, the carpal bones should still be preserved. A *tendoplastic* operation may be done, if the tendons can be saved, and the tendons used to operate upon a prosthetic apparatus. If this is not done, at least the tendons should be sutured to the carpal bones directly or through the soft parts of the stump so that the muscles may operate upon the carpus.

Disarticulation of the first metacarpal bone with the thumb is best done by the racket incision. The incision begins on the dorsal aspect of the hand just above the first carpometacarpal joint, and passes down the back of the thumb as far as the middle of the metacarpal bone where it divides as a Y. The two arms of the incision pass obliquely around the thumb at the web (Fig. 1930, *E*). At the upper end of the incision care should be taken not to wound the radial artery which lies directly under it; the incision should pass only through the skin. The incision elsewhere is carried down to the bone on a line with the retracted skin. The tendons should be cut long. The soft parts should be cleared from the metacarpal bone. After division of all of the tendons, the disarticulation is accomplished by dividing the ligaments of the joint. The main artery and the dorsal artery of the thumb are tied. The thenar muscle mass is sutured together. The long flexor and extensor tendons are sutured in the wound or are preserved for tenoplastic operation. The wound is closed, leaving a dorsal linear scar.

Disarticulation of second metacarpal bone with the first finger is done by the racket incision. The incision begins in the dorsal aspect of the hand just above the second carpometacarpal joint, and passes down the back of the second metacarpal bone as far as the middle of the bone where it divides as a Y. The two arms of the incision pass obliquely downward and then turn across the palmar surface on a level with the free edge of the web. The flap on the radial side should be made a little broader than the other so as to bring the scar farther from the palm. The tendons should be cut long for suturing. On account of the broad base of the metacarpal bone, a short transverse incision may be made at the upper end of the vertical incision in order to facilitate the disarticulation. The arteries requiring to be ligated are the digital, the indicis radialis and the indicis dorsalis.

Disarticulation of fifth metacarpal bone with the little finger is done by the same principle as for the first finger. The longitudinal incision should not be on the ulnar side but should lie over the middorsal line of the metacarpal bone. The arteries to be tied are the two digital. The hypothenar muscles should be sutured together. The synovial sac should be closed.

Disarticulation of third or fourth metacarpal bones with their fingers is done by the racket incision. The incision begins above the carpometacarpal joint, follows the back of the bone to its middle, where it divides into two arms which obliquely pass down to the web and thence transversely across the palmar surface at the level of the free border of the web (Fig. 1930, *F*).

Disarticulation of second and third metacarpal bones with their fingers is similar to disarticulation of a single metacarpal. The upper end of the ver-

tical incision is between the two metacarpals. It begins above their carpo-metacarpal articulations. The incision passes down between the two bones on the back of the hand. Opposite the middle of the metacarpals it divides. The two diverging arms pass obliquely downward to the level of the web, and thence turn transversely across the palmar aspect at the level of the base of the fingers. A transverse incision should be added at the upper end of the vertical incision to facilitate disarticulation (Fig. 1930, *G*). The incisions are deepened and the bones cleared of soft tissues. The metacarpals are cut loose from their metacarpal and carpal attachments and removed. The tendons are cut long. The vessels are tied, and the tendons and flaps sutured in place.

Disarticulation of second, third and fourth metacarpal bones with their fingers may be done with the *racket incision*, the same as above, the vertical arm lying on the back of the third metacarpal. The upper end of the incision should be crossed by a transverse incision at right angles, to facilitate disarticulation.

Disarticulation of third, fourth and fifth metacarpal bones with their fingers may be done with the *racket incision*, the same as the above, or with a *short palmar flap*. When done by the latter method, the palmar incision begins at the ulnar border of the hand just below the base of the fifth metacarpal bone, and passes to the web between the first and second fingers with a slight curve having its convexity toward the ulnar side. The dorsal incision connects the two ends of the palmar incision but curves in the opposite direction, having its concavity toward the ulnar side (Fig. 1934, *A*). The bones are cleared of soft tissues and the tendons cut long. Disarticulation of the fourth and fifth metacarpals is not difficult, but to disarticulate the third the soft tissues must be strongly retracted. Care should be taken not to injure the deep palmar arch. The palmar synovial sheath should be sutured where it is opened, the interosseous branches of the palmar arch ligated, the hypothenar muscles sutured together, and the tendons united across the stump. As the skin incision is sutured, the scar lies on the dorsum of the stump. As injury is the common cause of this amputation, the size and shape of the flaps must vary with the tissue available.

FIG. 1934.—AMPUTATIONS IN THE HAND.

A, Disarticulation of third, fourth, and fifth metacarpal bones; *B*, disarticulation of four last metacarpal bones.

Disarticulation of all of the finger metacarpal bones is done by much the same incision as the above. A *short palmar flap* is to be preferred. The palmar incision begins at the ulnar side of the hand just below the base of the fifth metacarpal bone. It curves downward, marking out a palmar flap, and ends at the web, midway between the bases of the thumb and index-finger. The dorsal incision connects the two extremities of the palmar in-

cision, but curves upward instead of downward (Fig. 1934, *B*). The tendons should be cut long to be used for tendoplasty or sutured across the stump. Care should be taken to spare the palmar arches from injury. The nerves should be divided high. The arteries requiring ligation are the palmar digital, palmar interosseous, indicis dorsalis and indicis radialis. The flexor sheaths should be closed. The convex palmar flap is sewed to the concave dorsal flap, giving a dorsal scar.

Disarticulation of all metacarpal bones at carpometacarpal joint is done by a *double flap operation*—long palmar and short dorsal. The upper limit of the incisions on the ulnar side of the hand is at the unciform-metacarpal joint, and on the radial side at the trapeziometacarpal. The palmar flap is marked out by an incision connecting these two points and curving downward across the palm opposite the necks of the metacarpal bones. The dorsal incision curves across the back of the hand at a slightly higher level than the palmar incision, crossing the metacarpals at about the junction of their upper and middle thirds. The steps of this operation are the same as disarticulation at the wrist except that the incisions are made lower (see below).

Amputations at the Wrist.—For *Anatomy* of Tendons and Bursal Sacs, see page 447. For Bones, see hand. For Vessels, see Vol. I, page 421.

The important vessels are the radial artery, giving off its superficialis volæ, posterior carpal and metacarpal branches; the ulnar artery, giving off its anterior carpal, posterior carpal, carpal branch of anterior interosseous and posterior terminal branch of anterior interosseous; and the carpal recurrent branch from the deep palmar arch. The radial artery lies between the tendons of the flexor carpi radialis and supinator longus, and rests upon the lower end of the radius whence it winds round the wrist under the extensors of the thumb, and enters the palm between the first and second metacarpal bones. The ulnar artery lies between the tendons of the flexor carpi ulnaris and flexor sublimis digitorum and rests upon the annular ligament external to the pisiform bone.

Disarticulation at the wrist-joint is not to be done if disarticulation at the carpometacarpal joint is feasible. It is much to be preferred to amputation in the lower part of the forearm because a better stump can be made and pronation and supination are preserved. The styloid processes of the radius and ulna should be preserved. The radial styloid gives attachment to the important supinator longus. A palmar flap forms the best covering for the bones. Tendons should be preserved, and tenoplasty to give a motor stump considered.

With a palmar flap, the radial end of the incision is at a point 1.3 cm. ($\frac{1}{2}$ inch) below the styloid process of the radius; the ulnar end is the same distance below the styloid process of the ulna. These two points are connected by a palmar incision having somewhat more the form of horseshoe than a U. Its lower border should pass across the palm at the middle of the middle metacarpal bones. The dorsal incision connects the same two points by a line with a slight upward convexity (Fig. 1935). The first incisions pass through skin and fascia. The deeper incision is made at the upper level of the retracted skin. It passes through the thenar and hypothenar muscles and exposes the flexor tendons. This flap, containing the thick palmar areolar tissue and the palmar muscles, is dissected up as far as the joint. The dorsal flap is made by deepening the incision to the bone, and dissecting up all of the divided tissues as far as the joint.

The level at which the long tendons are cut depends upon the disposition that is to be made of them. They may be preserved as long as possible for a tenoplastic motor stump; they may be cut long enough to be sutured across the ends of the bone or united to the flap; or they may be cut at the extreme upper level, as is the usual practice, allowed to retract, and the muscles of

the forearm allowed to fall into degeneration. If time and surgical limitations or limitation of tissue available, do not permit planning a motor stump, the next best thing is to unite the flexor tendons to the extensor tendons across the ends of the bones. The ligaments of the joint should be divided and disarticulation completed. The palmar flap is turned back and sutured to the dorsal flap. As in all disarticulations with exposure of synovial membrane, drainage should be provided for the first two days.

In this operation the palmar flap may be made shorter and the dorsal incision carried horizontally across the wrist. The extent of tissue available must influence the method employed.

With double flaps, one a long palmar flap and the other a short dorsal flap, the incisions are made as in the above operation, excepting that the palmar flap is shortened to the same degree that the dorsal flap is lengthened, so that the total flap length shall be the same. In these flap operations, care should be taken that the flaps are not cut too narrow; it should be borne in mind that the flaps contract in their lateral as well as long axis. For this reason the lateral lines should diverge slightly as they pass downward.

With a long palmar and short dorsal flap the scar falls posteriorly. A long posterior flap may be used. This is made of thin skin, but is preferable to having the scar at the end of the stump.

With a lateral flap, the covering may be taken from the radial or ulnar side of the hand. If a *radial flap* is taken the palmar incision should begin about 1.3 cm. (½ inch) below the wrist joint at a point equidistant from the radial and ulnar sides of the wrist. This incision should pass downward along the inner border of the thenar eminence, outward across the neck of the first metacarpal bone, and thence upward and inward between the first and second metacarpals to a point on the back of the hand 1.3 cm. (½ inch) below the joint and equidistant between the tips of the radial and ulnar styloid processes. From the two ends of this incision a transverse incision passes around the ulnar half of the wrist (Fig. 1930, *H*). When necessary an *ulnar flap* of similar size and shape may be used instead of a radial flap, the lines of the operation being reversed.

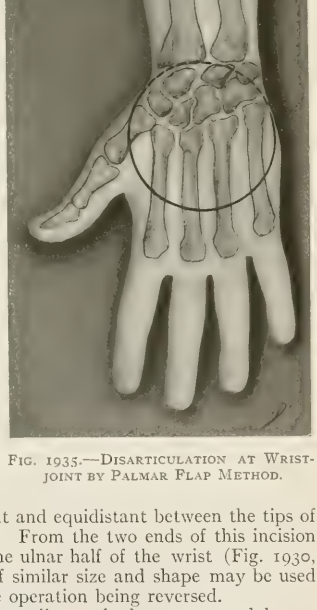


FIG. 1935.—DISARTICULATION AT WRIST-JOINT BY PALMAR FLAP METHOD.

Amputations of the Forearm.—The radius and ulna, connected by an interosseous membrane, divide the forearm into two parts—anterior and posterior. There are two distinct muscle groups separated by these structures—the anterior and the posterior. The arteries of the forearm (Vol. I, page 421), are the radial, with radial recurrent, muscular, anterior carpal, superficialis volæ, and posterior carpal branches; and the ulnar, with ulnar recurrent, interosseous, muscular, and carpal branches. They lie between

the muscles. The deep veins are two venæ comites with each artery. The superficial veins lie directly under the skin (Fig. 1936).

The muscular mass which occupies the upper two-thirds of the forearm becomes largely tendinous in the lower third. Thus in the lower third, flaps are devoid of muscle, and the most commonly applied method of amputation is the circular. In the upper two-thirds, flaps are used. The flaps should be long enough to allow free space at the ends of the bones. Even a short forearm stump is better than disarticulation at the elbow. As much of the bones as possible should be saved. If the bones are sacrificed above the insertion of the pronator radii teres pronation and rotation is lost and the radius becomes fixed in supination. The stump should be dressed with the elbow immobilized on a right-angle splint.

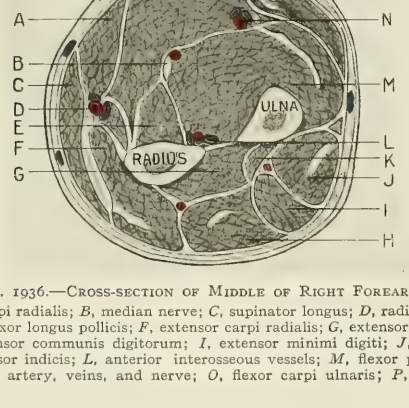


FIG. 1936.—CROSS-SECTION OF MIDDLE OF RIGHT FOREARM.

A, Flexor carpi radialis; *B*, median nerve; *C*, supinator longus; *D*, radial artery, veins, and nerve; *E*, flexor longus pollicis; *F*, extensor carpi radialis; *G*, extensor ossis metacarpi pollicis; *H*, extensor communis digitorum; *I*, extensor minimi digiti; *J*, extensor carpi ulnaris; *K*, extensor indicis; *L*, anterior interosseous vessels; *M*, flexor profundus digitorum; *N*, ulnar artery, veins, and nerve; *O*, flexor carpi ulnaris; *P*, flexor sublimis digitorum.

In the forearm the cinematic stump may be made. No forearm should be amputated without considering the possibilities of tendoplastic operations (see page 526). Osteoplastic operations may often be done to advantage upon the bone-ends, and a better stump with better powers of rotation secured (see page 524). The tendoplastic and osteoplastic operations have been described above. Below will be described only the older methods, independent of their cineplastic possibilities. These older typical operations must lend themselves to modifications for the production of motor stumps.

Amputation in lower third of forearm by the circular method is described above (page 505). In the lower third of the forearm the skin-fascia flap may be turned back by the *cuff method* without notching the flap, or the outer and inner sides of the cuff may be notched, thus producing a *double flap*. It is important that the total distance from saw line to the end of the flap shall be equal to three-fourths of the diameter of the arm at the saw line (Fig. 1937, *A*).

After retracting the skin flap the underlying tissues are commonly divided

down to the bone at a level midway between the skin incision and the saw line. The soft parts are pressed back from the bone and the bones divided. The radial, ulnar, and anterior and posterior interosseous arteries require to be tied. The arm should be put up on a right-angle elbow splint.

Amputation in upper two-thirds of forearm may be done in a thin arm by the circular method (page 506). In a muscular tapering arm it is best done with *equal flaps* (Fig. 1937, *B*). Each flap should have a length equal to three-fourths the circumference at the saw line. An ordinary scalpel is used. The first incisions pass through skin and fascia. As the skin retracts, the muscle is divided at the upper level of the retracted skin. In a heavy arm the muscles should be cut at two distinct circular levels, the deeper muscles being cut after the superficial muscles have retracted (see Circular Amputation, page 505). The median, radial, and ulnar nerves should be drawn down and cut high. The soft parts are elevated from the bone, retracted, and the bones sawed. The radial, ulnar, anterior and posterior interosseous arteries should be tied.

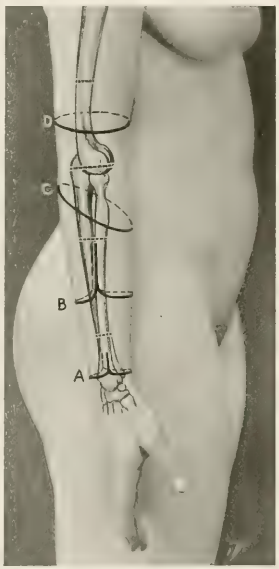


FIG. 1937.—AMPUTATIONS OF FOREARM.

A, Amputation in lower third of forearm by the cuff method; *B*, amputation in upper part of forearm with equal flaps; *C*, disarticulation at elbow by oblique circular method; *D*, circular amputation of arm.

Disarticulation at the Elbow-joint.—The elbow-joint is formed by the humerus above and the ulna and radius below. The important arteries near the joint are, the brachial with its superior profunda, inferior profunda, and anastomotica magna branches; the radial with its radial recurrent branch; and the ulnar with its anterior and posterior recurrent branches. The brachial artery lies internal to the tendon of the biceps. The ulnar nerve and the posterior ulnar recurrent artery lies in the groove between the olecranon and the inner condyle. The musculospiral nerve and superior profunda artery lie in front of the outer condyle. The median nerve lies internal to the brachial artery. There is a bursa between the olecranon process and the skin, and one between the triceps and the tip of the olecranon. The epiphyses about the joint unite to their shafts from the sixteenth to the seventeenth year (Fig. 1938).

The line of the joint is found by feeling the head of the radius during pronation and supination, and then identifying the depression above it on the posterior surface of the joint. The joint is more easily opened and the disarticulation begun on the outer side. On the anterior surface the crease made by the fold of the elbow is a little above the level of the joint. The extended elbow has an angle directed inward, as a result of which the inner condyle is more prominent than the outer; the two condyles and the top of the olecranon process of the ulna are on the same horizontal plane. The

lower end of the humerus is large, and no mistake should be made in the allowance of skin for its covering. It is of value to preserve the articular end of the humerus; a much more useful stump is secured than by amputating above the elbow. On account of the synovial surface, drainage for a short time should be provided. The stump should be placed at rest on a pillow.

Methods of making flaps at the elbow should depend upon the skin available. The posterior skin is tougher than the anterior and accordingly the operation of choice is with a *long posterior* and *short anterior flap*. Next in preference is the *posterior ellipse*, which is a long posterior flap fitting into an anterior concavity.

Other methods are by *long anterior and short posterior flaps, anterior ellipse, long posterior flap, long anterior flap, single external flap, single internal flap, equal lateral flaps, long and short lateral flaps, lateral ellipse, circular, racquet, and short antero-internal and long postero-external flaps.*

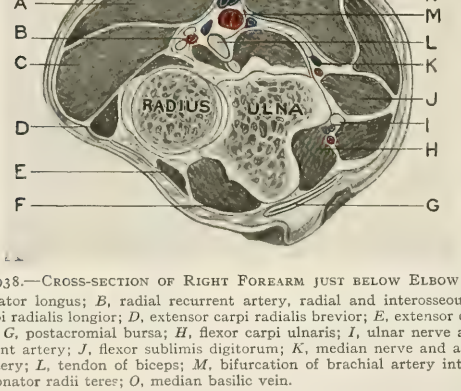


FIG. 1938.—CROSS-SECTION OF RIGHT FOREARM JUST BELOW ELBOW JOINT.

A, Supinator longus; *B*, radial recurrent artery, radial and interosseous nerves; *C*, extensor carpi radialis longior; *D*, extensor carpi radialis brevior; *E*, extensor carpi ulnaris; *F*, anconeus; *G*, postacromial bursa; *H*, flexor carpi ulnaris; *I*, ulnar nerve and posterior ulnar recurrent artery; *J*, flexor sublimis digitorum; *K*, median nerve and anterior ulnar recurrent artery; *L*, tendon of biceps; *M*, bifurcation of brachial artery into radial and ulnar; *N*, pronator radii teres; *O*, median basilic vein.

Disarticulation of elbow by long posterior and *short anterior flaps* is made with flaps marked by incisions beginning laterally 2.5 cm. (1 inch) below the condyles. The posterior flap is cut by carrying the incision downward and then curving across the back of the forearm to join a similar incision from the other side. The anterior flap has the same shape but is one-half the length of the posterior flap. The total length of the two flaps should be 1½ times the diameter of the arm at the condyles. The relative lengths of these two flaps may vary anywhere between that of a single flap and equal flaps.

The muscles are cut on the line of the retracted flaps, and all of the soft tissues dissected from the bones up to the joint line. Ligaments should be left attached to the muscles, and muscles should be left attached to the skin. The ligaments of the joint are divided as low as possible. As the elbow is flexed the ligaments of the head of the radius are divided posteriorly and the joint opened. From this point the incision into the joint is carried around

the olecranon. Then the joint is extended and the disarticulation completed anteriorly. The vessels should be tied, and the muscles of one flap sutured to those of the other. Over all, the skin is sutured with provision for drainage.

Disarticulation at the elbow by oblique circular method is simple, and can be carried out quicker than the flap operations (Fig. 1937, *C*).

Disarticulation of the elbow by a posterior ellipse is begun by marking out the skin flap with a continuous incision. The upper limit of the incision is anteriorly opposite the condyles. The lower limit is posteriorly a distance below the joint line equal to one and one-half diameters of the arm at the condyles. This makes the flap 8 or 10 cm. (3 or 4 inches) long. The incision is made with a small scalpel. It begins at the upper limit with the joint flexed at a right angle, passes obliquely down the inner side of the joint, thence obliquely downward to its lower limit, and upward on the outer aspect of the limb to the starting point. The muscles are then divided on the line of the retracted flap. The posterior mass of muscles included in the flap are retained adherent to the skin and dissected free from the bone. When the dissection upward reaches the ligaments of the joint they are divided and left attached to the muscle. Disarticulation is completed and the muscles are turned forward and sutured over the articular surface. The skin flap is then sutured over the articular surface. The skin flap is then sutured, the convex lower end of the flap fitting into the concavity anteriorly (Fig. 1939). Drainage should be provided for two days.

Fig. 1939.—Disarticulation at Elbow by Posterior Elliptical Flap.

Amputations of the Arm.—The humerus is the only bone involved. The important anterior muscles are the biceps, coracobrachialis, and brachialis anticus. Posterior muscles are the triceps. Shoulder muscles inserted into the upper part of the humerus are the scapular muscles, pectoralis major, deltoid, and latissimus dorsi. From the region of the external condyle pass the supinators and extensors of the forearm, hand and fingers. From the region of the internal condyle pass the pronators and flexors of the forearm, hand and fingers.

The arteries are the axillary and brachial with their branches (see Arteries, Vol. I, page 416). The important nerves are the median, musculospiral, ulnar, musculocutaneous, internal cutaneous, intercostohumeral, and circumflex (Fig. 1940).

Cineplastic amputations with the purpose of securing a motor stump are always to be considered in arm amputations. Whatever sort of operation is done as much of the humerus as possible should be saved. A very short

stump is better than disarticulation at the shoulder-joint. A short stump can be of some service in moving an artificial arm; and amputation is less dangerous than higher disarticulation. Amputation as high as the surgical neck still gives a stump capable of movement. In very high operations the synovial membrane of the joint which covers the tendons of the biceps and triceps may be opened. When a short stump is made the muscle which is inserted below the saw line may still be saved and sewed across the bone end to contribute to its motility. The end of the stump has no bearing function as prosthetic apparatus passes up to the axilla. The lateral aspects of the stump sustain the most pressure. For these reasons a terminal scar is not undesirable. In cutting flaps it should be borne in mind that the anterior tissues retract more than the posterior because of the presence of the freely movable biceps. In the lower third the muscles are more fixed, and circular amputation is preferred. In the upper two-thirds the muscles are more movable, and flap operations are preferred.

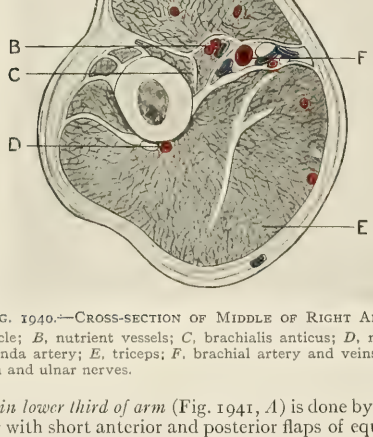


FIG. 1940.—CROSS-SECTION OF MIDDLE OF RIGHT ARM.

A, Biceps muscle; *B*, nutrient vessels; *C*, brachialis anticus; *D*, musculospiral nerve and superior profunda artery; *E*, triceps; *F*, brachial artery and veins, inferior profunda artery, and median and ulnar nerves.

Amputation in lower third of arm (Fig. 1941, *A*) is done by the modified circular method or with short anterior and posterior flaps of equal length. The lower border of the flaps should be below the level of the saw line a distance equal to three-fourths of the diameter of the arm at the saw line. The flaps are cut as for circular amputation except that a notch is made on either side, thereby converting the cuff into two flaps. It is not necessary that the flaps be anterior and posterior and the notches lateral. The flaps and the notches may lie in any position so long as they are symmetrical. Such modification is often made necessary by the nature of the disease or injury.

The flaps are marked out with a scalpel which incises skin and fascia down to the muscle. As the cut structures retract, the muscle is cut half through on a circular level with the lower border of the flap. The superficial layer of muscle having retracted, the rest of the muscle is cut a little higher, down to the bone. The muscle still covering the bone is dissected away from

the bone as high as the saw line and the bone is divided. The arteries requiring to be tied are the brachial, superior profunda, inferior profunda, anastomotica magna and muscular. The nerves should be cut short. The muscles should be sewed over the end of the bone, and the flaps sutured. Drainage may be provided for two days.

Amputation in middle third of arm is done with two unequal flaps. It may be done with equal flaps. The flaps may be lateral (Fig. 1942, *A*) or in any other position which circumstances provide. Commonly as a matter of choice, a long anterior and short posterior flap are used (see Flap Opera-

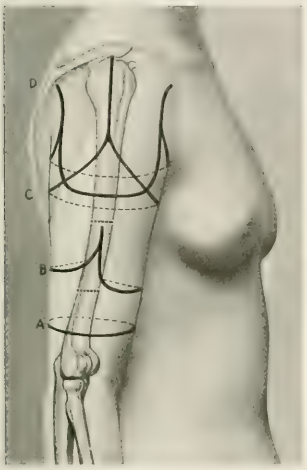


Fig. 1941.

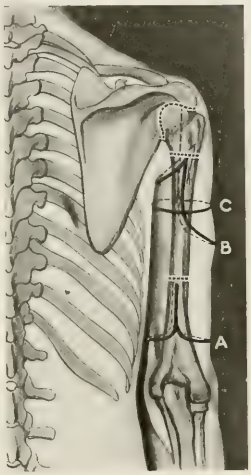


Fig. 1942.

Fig. 1941.—Amputation of Arm.

A, Circular amputation of lower third; *B*, long anterior and short posterior flaps; *C*, disarticulation of shoulder by external racket incision; *D*, disarticulation of shoulder by external flap.

Fig. 1942.—Amputations through Arm.

A, Amputation with lateral flaps; *B*, amputation in upper third with long external flap; *C*, circular amputation in upper third. Either of these last two operations may be concluded as a disarticulation at the shoulder.

tions, page 507). The flaps should each represent at their bases half the circumference of the limb. The anterior flap should be twice the length of the posterior, and should be as long as the diameter of the limb at the saw line. The flaps are marked out with a scalpel as the arm is held up by an assistant. The brachial artery should lie in the anterior flap. In amputations above the middle of the arm the brachial artery which lies along the inner side may be split by the vertical incision. This is not a matter of consequence so long as it is properly cut and ligated. It is much more important that the nerves should not be split and left ragged in the flaps. They should be identified and cut off high above the surfaces of the flaps. The

muscle is cut with the flap. In suturing, the muscle is sewed over the end of the bone (see Muscle-skin Flaps, page 504).

Amputation in the upper third of arm is done as high as the surgical neck of the humerus. It is best done with a *single external flap*. It may be done with anterior and posterior flaps. When the amputation is done at the surgical neck, the patient lies on the back with the arm abducted at a right angle. An external flap is cut, the upper limits of the vertical incisions being at anterior and posterior opposite points. These points should be about 2.5 cm. (1 inch) below the saw line. These lines of incision pass downward parallel with the bone and then curve outward to a point on the outer side of the arm at such a position that the length of the flap shall be equal to the diameter of the limb at the level of the saw line. The inner incision connects the upper ends of the outer incision, and passes obliquely downward and inward across the line of junction of the arm and the thorax in the axilla (Fig. 1942, *B*). These incisions are made with a narrow scalpel and pass only through skin and fascia. The muscle is next divided on a line with the retracted skin.

Hemostasis in this operation is best secured by pressure upon the axillary artery and shoulder through a rubber-cord tourniquet. This may be held from slipping by means of a bandage around the thorax or by means of long pins thrust through the soft parts of the shoulder. The experienced surgeon does not need these devices, but clamps vessels as they are exposed in the progress of the operation, ligating the brachial artery as it is uncovered through the anterior arm of the internal incision.

It is desirable that the tendon of the pectoralis major should be saved. If the saw line falls above its insertion, the periosteum with the insertion of the tendon and the surrounding soft structures should be stripped up and left in the flap; or the portion of the bone represented by the bicipital groove should be sawed or chiseled free and the insertion of the tendon preserved by osteoplastic. If this is not done, the tendon should be sutured to the structures on the outer and front sides of the bony stump. The tendons of the latissimus dorsi and teres major should likewise be preserved or reattached to the bone. By dividing the biceps and coracobrachialis low down the synovial membrane of the joint may be avoided.

By making the incision low the circumflex nerve and the posterior circumflex artery are spared. The muscle having been divided down to the bone, the outer flap is retracted and lifted up as far as the saw line. The soft parts of the inner wound also are retracted to expose the bone. A spatula is passed round the bone to protect the axillary and brachial vessels, and the bone is sawed through, sparing as much of it as possible. The brachial vessels may be tied before the bone is sawed or afterward. The artery should be tied separately from the veins. The nerves are all close to the artery; they should be identified, drawn down, and cut short. They are the musculocutaneous, internal cutaneous, median, ulnar, and musculospiral. In suturing the wound the muscles should be sewed across the end of the bone. The skin should be sutured separately.

This operation may be done by an anterior racket incision. Such an incision gives an opportunity to tie the vessels as a preliminary step, and may be carried out without constriction.

Disarticulation at Shoulder.—The shoulder-joint is at the junction of the humerus, scapula and clavicle. The important artery is the axillary, for the relations of which see Vol. I, page 415. Other arteries are the subscapular, transversalis colli, superior thoracic, acromial thoracic, long thoracic, alar thoracic, subscapular, anterior circumflex and posterior circumflex. Veins accompany the arteries. The important nerve trunks lie about the

axillary artery, and are musculocutaneous, internal cutaneous, median, ulnar, and musculospiral. Branches of the main arterial trunk, supplying the muscles and other structures about the shoulder, are the subscapular, transversalis colli, superior thoracic, acromial thoracic, long thoracic, alar thoracic, subscapular, posterior and anterior circumflex. These all require to be ligated (Fig. 1943).

The greater tuberosity of the humerus lies externally, the lesser tuberosity anteriorly. The numerous attachments covering these tuberosities make them difficult to feel in muscular persons. The inner and lower surface of the head of the humerus can be felt easily in the axilla. The upper epiphysis of the humerus unites to the shaft about the twentieth year. The surgical neck of the humerus is just above the insertion of pectoralis major and latissimus

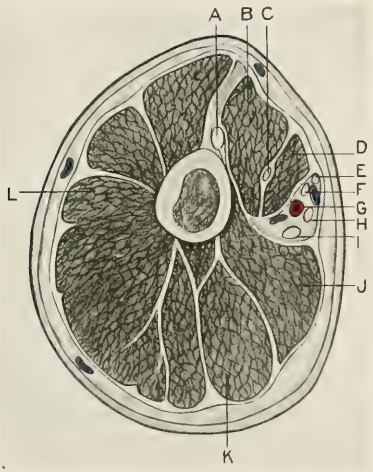


FIG. 1943.—CROSS-SECTION OF RIGHT ARM AT AXILLA.

A, Tendon of long head of biceps; *B*, short head of biceps; *C*, musculocutaneous nerve; *D*, coracobrachialis muscle; *E*, internal cutaneous nerve; *F*, median nerve; *G*, axillary artery and veins; *H*, ulnar nerve; *I*, musculospiral nerve; *J*, latissimus dorsi; *K*, triceps; *L*, deltoid

dorsi muscles, and below the tuberosities. The surgical neck is crossed transversely by the circumflex nerve and the posterior circumflex artery. This nerve by all means should be spared as it supplies the deltoid muscle. The course of the axillary artery may be determined by abducting the arm 45 degrees, rotating it outward, and drawing a line from the center of the clavicle to the groove on the inner side of the biceps.

For the *control of hemorrhage* in amputations at the shoulder, the rubber elastic cord is best. For this purpose a solid rubber cord or rubber tubing is used. It should be not less than 1.3 cm. ($\frac{1}{2}$ inch) in diameter, of new rubber which will not break. This tourniquet may be prevented from slipping by the use of long pins (Fig. 1944) or by a bandage around the thorax or it may be held by a few temporary sutures of silk passed through the skin

Fig. 1946). In the stead of these methods or in connection with them independent ligation of the axillary artery and vein may be done as a preliminary operation. This is not necessary unless there is some especial reason for adding this precaution. There is a growing tendency among progressive surgeons to go at once to the main artery and ligate it as a preliminary step; and then proceed through the same wound to inject the nerves with anesthetic. This having been done the amputation is then performed in the usual manner. The use of pins was first proposed by J. A. Wyeth. The anterior pin enters at a point slightly internal to the middle of the anterior axillary fold and emerges at a point 2.5 cm. (1 inch) internal to the tip of the acromion process. The posterior pin is entered at a corresponding point on the poste-

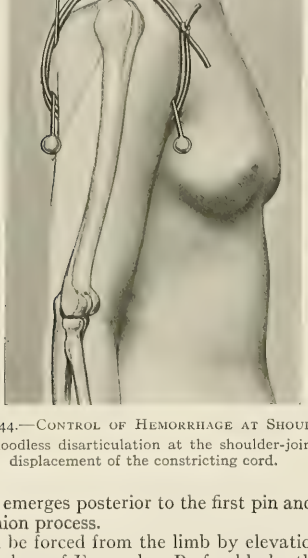


Fig. 1944.—Control of Hemorrhage at Shoulder.
This method permits bloodless disarticulation at the shoulder-joint. The pins prevent displacement of the constricting cord.

rior axillary fold and emerges posterior to the first pin and the same distance internal to the acromion process.

The blood should be forced from the limb by elevation, stroking, or the use of the rubber bandage of Esmarch. Preferably by the latter method.

Other methods of blood-control may be employed. The operation may proceed without tourniquet, and vessels may be ligated as they are exposed. This is apt to cause much loss of blood from small vessels. Digital compression of the main artery by an assistant just before the artery is cut is an old method, and still employed in hurried operations in which materials for constriction are not at hand. Digital compression of the subclavian artery against the first rib may be made by making an incision through the superficial tissues over the third part of the artery. Through this incision an assistant can control the vessel. The use of an axillary pad held against the axillary artery by an elastic tourniquet was formerly much used. For this

purpose heavy rubber tubing is used. Several turns of tubing are passed around the axilla and carried also across the chest as a figure-of-eight and under the opposite axilla. This may be supplemented by a bandage anteriorly and posteriorly to prevent slipping of the tourniquet (Vol. I, page 230).

In all of these methods, it should be borne in mind that as soon as the disarticulation is accomplished, the axilla and the shoulder are destroyed. A tourniquet, not having the mass formed by the upper end of the humerus to retain it, tends to roll away and release the vessels from compression. It is to guard against this that the above-described precautions are essential. The use of the pins of Wyeth is best security.

The *stump* should have as much muscular control preserved as possible. Wherever possible muscles should be preserved. Commonly the insertions of the pectoralis major, deltiod, latissimus dorsi and the scapular muscles can be preserved by elevating them from the bone with the periosteum. As much

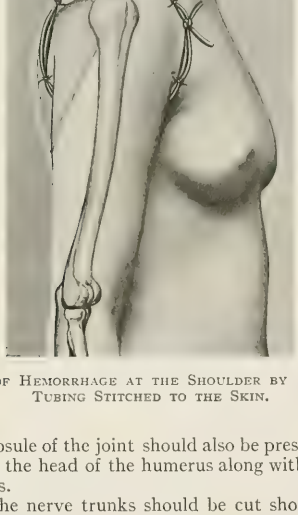


FIG. 1946.—CONTROL OF HEMORRHAGE AT THE SHOULDER BY MEANS OF TOURNIQUET TUBING STITCHED TO THE SKIN.

as possible of the capsule of the joint should also be preserved. This is done by elevating it from the head of the humerus along with the periosteum and the shoulder muscles.

The stumps of the nerve trunks should be cut short and allowed to retract higher than the vessels. Drainage for a few days is necessary because of the extensive synovial surface.

By retaining the acromion and coracoid processes, and the muscular attachments of the upper end of the humerus, a movable and useful shoulder results.

A motor stump may be formed here also. If there is available skin the terminal parts of the muscles may be isolated and covered with skin. This may be done with an anterior, a posterior and an external or abductor muscle mass (see Motor Stumps and Cineplastic Amputations, page 526).

Such muscles may be made to operate upon prosthetic apparatus and adjusted to flex and extend an elbow, flex fingers and abduct the arm.

Disarticulation of the shoulder by the anterior racket incision provides the the best access both to the vessels and the joint early in the operation. The patient should lie near the side of the table, the shoulder projecting somewhat over the edge. The head is flexed laterally toward the opposite side and the arm is slightly abducted. The arm should be rotated outward. The vertical incision begins above at a level with the top of the head of the humerus between the coracoid and acromion processes. It passes through the fibers of the deltoid and pectoralis major, as it is carried downward to the insertion of the latter muscle. The insertion of the pectoralis major is divided. At this point the incision divides, one branch passing downward and inward, the other passing downward and outward, to become a circular incision sweeping across the back of the arm just above the level of the insertion of the deltoid (Fig. 1947).

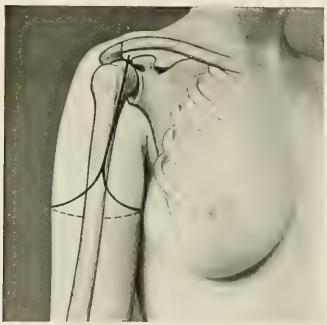


FIG. 1947.—DISARTICULATION AT THE SHOULDER BY ANTERIOR RACKET INCISION. This same incision may be used for high amputation through the humerus.

The vertical part of the incision exposes the joint and the bone. The incision may then be prolonged into its inner branch across the inner aspect of the arm and an axillary flap dissected up. Through this wound the vessels may be exposed, ligated and divided; and the nerves may be injected with anesthetic. The outer branch of the incision divides the deltoid muscle just above its insertion. The circumflex nerve to the deltoid is avoided by carrying the outer limb of the incision as low as the insertion of the muscle.

The vessels requiring ligation are the axillary artery, its two venæ comites and the basilic vein. In the vertical and external incision branches of the anterior circumflex, acromiothoracic and muscular arteries require to be tied.

Having ligated the vessels and divided them and the nerves, the incision passes down to the bone through the other soft structures. The muscles are separated from the bone by means of a sharp periosteal elevator, retaining as much periosteum as possible. Much of the separation of muscle from the bone is best accomplished through the vertical incision aided by rotation of the arm. The muscles inserted in the tuberosities are separated with their periosteum. As much of the capsule of the joint as possible should be left in

the flap. After opening the capsule and dividing the long head of the biceps, the head of the humerus is lifted out of the joint.

If the axillary vessels have not already been tied, an assistant, standing above the shoulder, controls the axillary vessels by placing one hand behind and the other in front of the shoulder and compressing the vessels with his fingers in the vertical wound. As the assistant compresses the vessels, the surgeon carries the incision around the inner side of the limb. The divided vessels are then held by the assistant in the inner flap, where they may at once be tied.

By preserving the muscles which cross the shoulder and are inserted into the humerus mobility of the stump is secured. The ends of these muscles should be sewed together. The more periosteum is preserved with these insertions the better the result. By keeping close to the bone the fewer vessels are divided. The skin flap should be sutured with provision for drainage.

Disarticulation of the shoulder by external racket incision is similar to the above operation excepting that the vertical incision is placed on the external aspect of the shoulder instead of the anterior (Fig. 1941, *C*). The vertical incision begins at the acromion process on the mid-outer aspect of the shoulder and passes downward a distance of 5 cm. (2 inches). From the lower end of this incision the two limbs pass obliquely downward to the end in a horizontal incision which crosses the axillary side of the arm on a level with a point 5 cm. (2 inches) below the place of bifurcation of the vertical incision. The vertical incision penetrates the deltoid muscle to the bone and opens the shoulder-joint. The oblique and horizontal incisions are carried at first only through skin and superficial fascia.

The anterior branch of the incision is carried through the deltoid and pectoralis major at its insertion. The coracobrachialis and biceps are divided. This should be done carefully as the vessels lie along the inner side of these muscles. The vessels are exposed, ligated and divided. The nerve trunks are divided. This inner flap is then dissected free up to the joint. In separating muscles from the bone, periosteum should be left attached to the muscle wherever possible. The outer flap is freed in the same way, dividing muscles down to the bone in the line of the skin incision. The capsule of the joint is retained with the muscles and periosteum. The head is lifted out of the joint and disarticulation completed.

This operation cuts the circumflex nerve and vessels. Other means of controlling the brachial artery may be employed, but its ligation as an early step in the operation is to be preferred.

Disarticulation of shoulder by external flap differs but little from the anterior racket incision. It also preserves the deltoid muscle. The incision which marks out the deltoid flap begins in front of the coracoid process, passes downward in front of the shoulder and crosses the outer side of the arm just above the insertion of the deltoid. The posterior incision passes upward to the spine of the scapula at the base of the acromion process. This marks out a U-shaped flap (Fig. 1941, *D*).

The two arms of this incision are joined at the middle by another incision which crosses the inner aspect of the arm about 4 cm. (1½ inches) below the axillary folds. The axillary vessels are best tied through this latter incision. When that is to be done, the internal incision should be made first, and the external incision made after ligation of the vessels and injection of the nerves.

The external incision is deepened to the bone. The deltoid is cut at its insertion, and the heavy muscular mass included in the external flap is turned upward. The joint is opened, the capsular ligament divided and the head lifted out of the socket. The cutting of the internal flap is then completed.

Amputation of the shoulder (interscapulothoracic amputation) consists in the removal of the arm together with the scapula and the whole or part of the clavicle. It is an amputation between the shoulder and the thorax. Usually the outer two-thirds of the clavicle is removed. The shoulder joint is not disarticulated.

The patient should lie on his side at the extreme upper end of the table and at the extreme edge. The arm should lie by the side, or the patient may lie on his back and be rotated to the side at the last stage of the operation. An incision should be made along the upper surface of the clavicle over the outer two-thirds of the bone. Some superficial veins require to be tied. This incision should pass through the periosteum of the clavicle. The periosteum with its attached structures should be stripped from the bone, the bone disarticulated at the acromioclavicular joint, and sawed in two at the junction of its middle and inner thirds (see Resection of Clavicle, Vol. I, page 729). The elevation of the periosteum is done with a curved periosteal elevator. The bone is best divided with a wire saw. The subclavian vessels should be protected from injury by means of a spatula. The incision should extend slightly beyond the outer extremity of the bone (Fig. 1948).

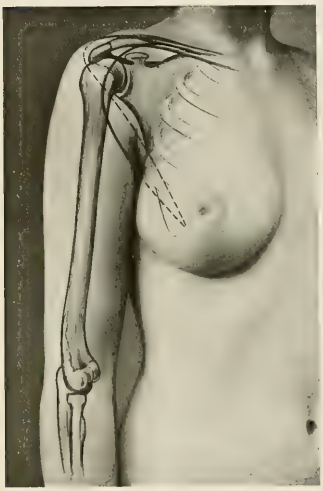


FIG. 1948.—INTERSCAPULOTHORACIC AMPUTATION OF SHOULDER.

The dotted lines indicate that part of the incision which is posteriorly.

The subclavius muscle and the periosteum lying over the subclavian vessels are picked up, divided and lifted away from the vessels. The vessels are found in the underlying connective tissue. The subclavian artery is ligated in its third portion, opposite the lower border of the first rib. Here it has in front of it the external jugular, suprascapular and transverse cervical veins, the descending branches of the cervical plexus and the suprascapular artery. Behind is the scalenus medius muscle. Above is the brachial plexus and the omohyoid muscle. Below is the first rib. The subclavian vein lies below the artery and slightly anteriorly. The lower cord of the brachial plexus should be identified. The subclavian artery and vein should be doubly ligated separately and divided. The artery should be tied first (see Ligation of Subclavian Artery, Vol. I, page 413).

The suprascapular and the posterior scapular arteries also should be tied. This insures an almost bloodless operation. Through this wound the cords of the brachial plexus should be identified and injected with anesthetic.

Two incisions should then be continued from the outer end of the clavicular incision. The first of these should form the anterior flap. This incision passes from the outer end of the first incision at the acromioclavicular joint, curving downward to the anterior axillary fold at its junction with the

arm, across the inner side of the arm to the posterior surface of the scapula just above the lower angle. As the latter part of this incision is made the arm is abducted and the back exposed.

This incision should pass through the muscles down to the bone. The fibers of the deltoid are separated and the pectoralis major is divided through its tendon of insertion. The pectoralis minor is cut as the incision is deepened. The flap is drawn forward and the subclavian structures again come into view. The cords of the brachial plexus are divided just external to the first rib. The dissection is carried backward through the axilla. The latissimus dorsi is divided. This practically completes the amputation. The shoulder has dropped back, and all that remains is to incise the posterior parts. Up to this point the patient may be permitted to lie supine upon the table, and at the conclusion of the anterior dissection be rotated upon the opposite side, exposing the posterior scapular region.

The posterior incision begins just internal to the outer end of the clavicular incision, internal to the acromioclavicular joint, and curves downward across the acromion process and the outer border of the scapula to join the incision ending at the lower angle of the scapula. Through this incision should be divided the trapezius along its attachment to the spine of the scapula. The upper border of the scapula is now exposed and rendered prominent and the omohyoid muscle divided. The vertebral border of the scapula is then exposed and rendered prominent, and the levator anguli scapulæ, the rhomboidei and the serratus magnus divided. This completes the detachment of the part. The muscles passing from the scapula and clavicle to the arm are not cut.

By ligating the subclavian artery and vein as a preliminary step the dangers of hemorrhage are avoided. Ligation of the suprascapular and posterior scapular arteries at the same time prevents much of the bleeding which should follow the flap dissections. If they have not already been tied, the suprascapular artery may be ligated as it enters the supraspinous fossa over the upper border of the scapula, and the posterior scapular may be tied at the upper angle of the scapula, when these regions are exposed.

The wound is closed by suturing the muscular stumps together as far as possible. Over this the skin flaps are sewed. A small drain may be left in for a day or two. The dressings should make even and gentle pressure to obliterate spaces.

The *posterior approach* is especially useful in thick-necked and muscular persons. The feature of the operation is that instead of operating from in front and ligating the vessels as soon as the clavicle is divided, the approach is from behind, and the vessels are divided last. The patient lies on his back with the shoulder at the edge of the table and the shoulder rotated forward by means of sand-bags. An incision is made along the upper surface of the clavicle over its outer two-thirds. This passes outward across the acromioclavicular articulation. The arm is drawn in front of the chest, and the incision continues downward across the middle of the scapula to the lower angle of the bone. The arm is then abducted. The anterior incision begins at the junction of the middle and outer thirds of the clavicle, curves outward and downward across the outer side of the coracoid process, along the anterior border of the deltoid muscle, across the pectoralis major, to the junction of the anterior axillary wall and the arm; thence it passes transversely across the axillary side of the arm to the posterior part of the axilla, onto the chest, and ends at the lower angle of the scapula (Fig. 1949).

This incision passes through skin and superficial fascia. Vessels are clamped as they are exposed. The operator standing behind the patient and

above the shoulder reflects the posterior flaps and exposes the muscles inserted into the inner border of the scapula.

These muscles are divided close to the bone. This is quickly done with scissors. The posterior scapular artery is ligated near the upper angle and divided. The scapula should then be drawn away from the thorax and the trapezius and omohyoid muscles cut. The suprascapular vessels are tied and divided at the suprascapular notch. The clavicle is then divided at the desired point.

The nerve trunks and the vessels are now exposed. The nerves are divided. The subclavian artery is tied and cut between the ligatures. The vein is then exposed, doubly ligated and divided. Finally the pectoralis major and minor, the latissimus dorsi and the serratus magnus are divided.

FIG. 1949.—INTRASCAPULOTHORACIC AMPUTATION OF SHOULDER BY THE POSTERIOR METHOD

AMPUTATIONS OF THE LOWER EXTREMITIES

Position.—In amputations of the foot, the patient should lie supine with the foot beyond the end of the table. In amputations of the leg the most satisfactory position is the ventral decubitus. It permits flexion of the knee without lifting the thigh. The limb should be supported by an assistant's two hands; it is not necessary that it project beyond the foot of the table provided it can be abducted. In amputations of the thigh the thigh should project beyond the foot of the table, so that the surgeon may stand facing the amputated stump. High thigh amputations are best done in the supine position; low amputations, in the prone position.

Anatomy.—For Bones of Foot, see Fig. 1950. For Vessels of Foot, see Vol. I, page 445; of Leg, Vol. I, page 437; of Thigh, Vol. I, page 431. Further descriptions of bones will be found under Fractures, Dislocations and Operations on Bones and Joints.

Amputations of Toes.—The same principles are to be employed as in amputations of the fingers. It should be borne in mind that the distal end of the bone entering into the toe joints is rounded and fits into the concavity of the proximal end of the distal bone—as is the case in the fingers. In

order to cut into a metatarsophalangeal or a phalangeal joint on its dorsal aspect. When the joint is flexed at a right angle, the incision must be made fully a distance the thickness of the bone beyond the most prominent point of the bend. It should be remembered that the distal end of the proximal bone is the fixed point and the distal bone rotates around it.

The insertion of the tendons and their arrangement are similar to those in the hand. The flexor brevis of the great toe is inserted into the inner and outer side of the plantar surface of the base of the first phalanx. A sesamoid bone is present in each of its two tendons of insertion. The tendon of the long flexor of the great toe is inserted into the plantar surface of the base of the last phalanx.

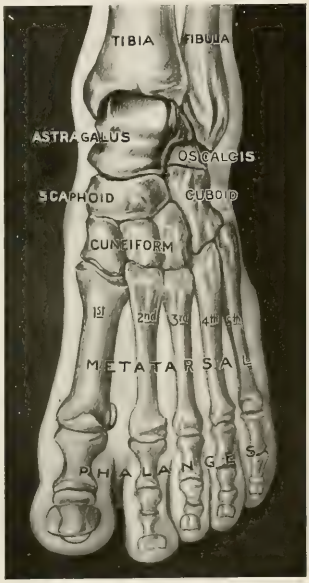


FIG. 1950.—BONES OF THE FOOT AND ANKLE, SEEN FROM ABOVE.

As much tissue as possible should be saved consistent with adequate nourishment. Every effort should be made to save the great toe as it is a most important organ in locomotion and in preserving the plantar arch. If it is destroyed or diseased to a degree calling for amputation, an osteoplastic operation should be considered whereby a new toe may be reconstructed.

What is still more important, the distal end of the first metatarsal bone should not be amputated without considering its osteoplastic reconstruction. This constitutes the anterior pedestal of the plantar arch; it should not be sacrificed.

In the other phalanges also the heads of the bone should be preserved if possible, but the great toe is the only one that can be regarded as important. The scars of operation should fall on the dorsal rather than the plantar surfaces, therefore plantar flaps are to be preferred. Where there is not enough skin to cover good bone, flaps and skin transplantations should be considered.

Amputated tendons should not be divided and allowed to contract. The flexor tendons should be sutured to the extensor tendons at the end of the stump or the tendons should be sewed to the periosteum or fascia of the last phalanx. This is to preserve the use of the muscles.

A narrow scalpel should be used. Flaps should be broad, so as to cover the bone ends without tension. Dorsal incisions should be made with the joints flexed, plantar incisions with the joints extended.

Toes can be amputated with local anesthesia. Drainage is necessary only in cases known to be infected. The flexor sheaths should be closed by suture.

Amputation of any of the four outer toes beyond the metatarsophalangeal joint leaves a short stump which has little value. Saving a part of these toes

leaves a stump which may become flexed or extended and prove to be a nuisance. Some surgeons in making all toe amputations disarticulate at the metatarsophalangeal joint excepting in the case of the great toe. This is perhaps doing more than is necessary in all cases. If the extensor and flexor tendons are equally preserved, to balance the stump, it is worth while saving the proximal phalanx in all cases.

In these small amputations the periosteum should be disregarded. Bones should be sawed, and not cut with bone-cutting forceps.

In disarticulations at the metatarsophalangeal joints a plantar flap should be used, the disarticulation should be made from the dorsum, the sesamoid bones should be left in place. In all cases the heads of the metatarsal bones should be left even though plastic covering from elsewhere must be

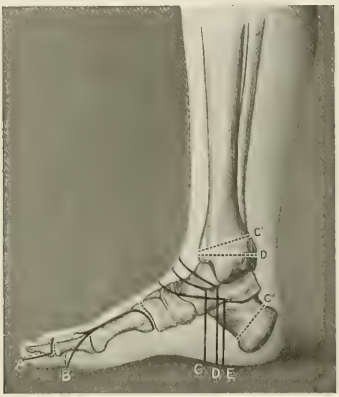


FIG. 1951.—AMPUTATIONS OF TOES AND FOOT (INNER SIDE).

A, Disarticulaton of end phalanx of great toe by long plantar flap. (For disarticulation at metatarsophalangeal joint this same incision is made higher.) *B*, Disarticulation of great toe and first metatarsal bone; *C*, inner view of incision for ankle disarticulation (Pirogoff); *C'*, line of division of bones of leg in Pirogoff's amputation; *C''*, line of division of os calcis in Pirogoff's amputation; *D*, inner view of incision for disarticulation of ankle (Syme); *D'*, line of division of bones of leg in Syme's amputation; *E*, subastragaloid disarticulation of foot with heel flap.

used to cover them. In dissecting up flaps the knife should be kept close to the bone to avoid injury to the digital arteries which lie near the bone.

Amputation through last phalanx is done only in the great toe. It is the same as in the fingers (page 545).

Disarticulation of end phalanges of toes is done with a plantar flap. The dorsal incision may curve slightly downward or be transverse (see Fingers, page 546) (Fig. 1951). The length of the flap should be 1½ times the diameter of the toe. The long lateral incision should be slightly nearer the dorsal than the plantar surface. The insertions of the flexor and extensor tendons should be secured before they are cut so that they may be preserved and sewed together across the end of the stump. This means that on the dorsum the tendon should be divided as far forward as its insertion, and on the plantar surface the periosteal insertion of the tendon should be

dissected up with the flap. With the joint in forced flexion it is opened on the top. The flexor tendon sheath should be closed with catgut. The plantar flap is turned up and sutured (Fig. 1952, *E*).

In the case of the *great toe* a long plantar flap is to be preferred but an internal lateral flap may be used. The *internal lateral flap* should have the same measurements as a plantar flap. It is taken from the inner side of the toe, has a breadth equal to a little more than one-half of the circumference of the toe, and a length 1½ times that of the diameter of the toe (Fig. 1952, *A*).

The lateral flap operation may be used in any toe amputation.

The above rules apply also to *disarticulation of the last two phalanges* of the last four toes.

Amputation through first phalanx is done in the great toe. Plantar flap, lateral flap, circular method, oval method, or racket method may be employed. These are applied the same as in the fingers. The same incisions are used as

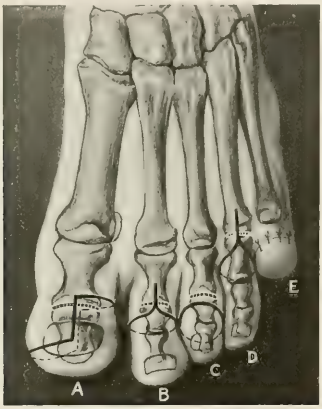


FIG. 1952.—AMPUTATIONS OF TOES.

A, Internal flap; *B*, racket incision; *C*, oblique circular incision; *D*, racket incision for disarticulation at metatarsophalangeal joint; *E*, showing plantar flap sutured after amputation is completed.

for disarticulation at metatarsophalangeal joint excepting that they are so much lower (Fig. 1952).

Disarticulation of great toe at metatarsophalangeal joint is best done by a racket incision (Fig. 1953). The incision begins over the middle of the joint on the dorsum of the foot. It passes forward along the junction of the upper and inner sides of the great toe as far as the head of the first phalanx, and thence curves around the inner, under, and outer surfaces of the toe to the web. Passing between the toes it is extended from the web backward and inward to the point of beginning.

This incision is deepened to the bone after dividing the flexor and extensor tendons at the middle of the first phalanx so that they may be sewed together across the end of the stump. The joint is opened on the dorsum. The capsular ligament should be divided close to the phalanx so as to leave as

much of it as possible for covering of the bone end. The sesamoid should be left in the stump. The flexor sheath should be closed. When the skin incision is closed the scar lies in the least exposed position. The operation may also be done with a long plantar flap (Fig. 1951, *A*).

Disarticulation of smaller toes at metatarsophalangeal joint is done the same as for the great toe. An elongated oval incision or a racket incision is used. It should begin just above the head of the metatarsal bone and pass around the toe at the web. The flexor and extensor tendons should be cut at the middle of the first phalanx and sewed together to preserve the function of the muscle (Fig. 1952, *D*). The joint is opened on the dorsum. The soft tissues to go into the flap are dissected close to the bone. The joint is about 2.5 cm. (1 inch) above the web. The flexor sheath should be closed with a catgut suture. The closed skin wound lies anterodorsally.

Disarticulation of two adjoining toes at metatarsophalangeal joint is by the same principle as in the hand. A racket incision is used the same as for one

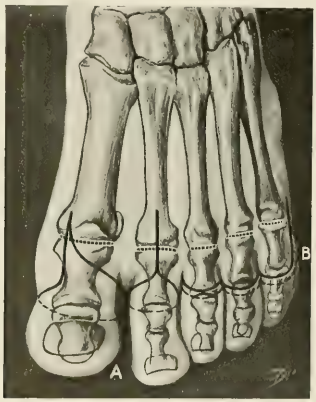


FIG. 1953.—DISARTICULATIONS OF TOES.

A, Metatarsophalangeal disarticulation of first and second toes; *B*, disarticulation of three last toes by dorsal and plantar flaps.

toe, excepting that the queue of the incision lies between the two toes and begins a little higher. The incision embraces two toes. The disarticulation, suturing of tendons, and closing of sheaths, are the same. The skin incision is closed as one longitudinal line. Or dorsal and plantar flaps may be used.

Disarticulation of more than two toes at metatarsophalangeal joints is best done with dorsal and plantar flaps as long as can be made. This operation applies also to any amputation of more than one toe (Fig. 1953, *B*). The dorsal incision should be made with the toes strongly flexed, the plantar incision with the toes strongly extended. Both the dorsal and plantar incisions pass across the bases of the toes just beyond the web, each toe incision being slightly curved to come back to the web and cross to the next toe. The extreme outer and inner ends of the incisions should be carried internally and externally as high as the metatarsophalangeal joints. When all of the

toes are amputated the ends of the incisions lie at the outer and inner border of the foot. When less than five toes are amputated at least one end of the incision should lie between two metatarsophalangeal joints.

The two flaps are of equal length. The two plantar and two dorsal digital arteries for each toe require tying. When the great toe is involved in the amputation, an extra amount of skin should be taken from the toe by curving the incision forward in order to secure adequate covering for the first metatarsal bone. When all of the toes except the fifth have to be sacrificed, the little toe may just as well be thrown in for good measure, as it can serve no more purpose than a wart on the stump.

Disarticulation of all toes at metatarsophalangeal joints is done with plantar and dorsal flaps of equal length (Fig. 1957). The incisions begin at the inner and outer sides of the foot opposite the metatarsophalangeal joint and mark out the largest possible plantar and dorsal flaps. To do this they take some tissue from the toes in the form of smaller flaps. The flexor and extensor tendons should be cut long enough to be sewed together across the ends of the metatarsal bones. The base of the first metatarsal of the great toe should be saved if possible.

Amputations of Foot.—For *anatomy* of Bones of Foot, see Fig. 1950. For Anatomy of Vessels, see Blood-vessels, Vol. I, page 445.

The dorsalis pedis artery is a continuation of the anterior tibial. It ends at the first intermetatarsal space, lying external to the tendon of the extensor proprius hallucis. The anterior tibial nerve lies external to it. The plantar artery is a continuation of the posterior tibial. It passes from its beginning, below the internal malleolus, forward and outward across the sole of the foot to the base of the fifth metatarsal bone. Thence it curves across the foot to the base of the first intermetatarsal space where it anastomoses with the communicating branch of the dorsalis pedis.

The plantar fascia is attached posteriorly to the os calcis and anteriorly it spreads out and divides into fine slips which are attached to the ligaments and tendon sheaths of the toes. The subcutaneous tissue of the foot is spongy areolar tissue, very thick and tough. It has great value as a stump covering and should be preserved whenever possible. Plantar flaps are to be preferred because of the toughness of the skin and in order to bring the scar on the dorsal surface.

The bony landmarks on the dorsum of the foot are not of much service. The head of the astragalus can be felt when the foot is extended. On the inner side the lesser process of the os calcis—the sustentaculum tali—can be felt 2.5 cm. (1 inch) below the inner malleolus. The tuberosity of the scaphoid in the adult foot lies a little over 2.5 cm. (1 inch) in front of the tip of the inner malleolus. The two ends of the first metatarsal bone can be felt. On the plantar surface the heads of the metatarsal bones can be felt in the ball of the foot. On the outer side of the foot the most prominent landmark is the base, shaft and head of the fifth metatarsal bone. The peroneal tubercle of the os calcis lies 2.5 cm. (1 inch) below the outer malleolus. The os calcis can be felt on all sides posteriorly.

The *metatarsophalangeal articulation* lies about 2.5 cm. (1 inch) posterior to the webs of the toes. The *tarsometatarsal articulation* passes obliquely across the foot. It is identified by finding the bases of the first and fifth metatarsal bones. The *mediotarsal joint*, limited posteriorly by the astragalus and calcaneus, is made up of two joints—the astragalo-scaphoid (internally) and the calcaneo-cuboid (externally). The latter is midway between the external malleolus and the base of the fifth metatarsal bone.

Rules for amputations in the foot are similar to those in the hand. Flaps should be cut so that scars do not fall upon the sole or other bearing surface. Plantar skin makes the best covering. The first and fifth metatarsal bones should be saved whenever possible, even though a plastic skin operation must be done to cover the bone. In amputations upon the young, the subperiosteal method should be used. Outside of the great toe there is little value in saving phalanges, but all metatarsal bones should be saved. Amputation through these bones is preferable to their removal.

Disarticulation at the tarsometatarsal joint gives a better stump than at the mediotarsal joint. Preserving the astragalus gives a better stump than

amputation at the ankle joint. Both astragalus and os calcis cannot well be preserved as the calf muscles draw the latter out of place, and even though they did not it projects too far posteriorly to be of service. Part of the os calcis may be preserved in some cases with advantage. The old operations which preserved the os calcis have been much relinquished. If the tarsal bones cannot all be saved to give something of an anterior support, the os calcis may as well be removed. The alternative is an osteoplastic operation to shift forward the backward-projecting os calcis.

Amputations and disarticulations of metatarsal bones should not be done without first considering replacing the removed bone by a plastic transplant from elsewhere. Indeed, these operations had better be described as osteoplastic operations rather than as amputations. They have always been in bad company among the amputations.

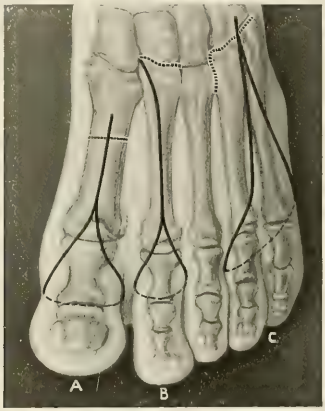


FIG. 1954.—AMPUTATIONS IN THE FOOT.

A, Amputation of toe with part of metatarsal bone; *B*, amputation of toe with whole of metatarsal bone; *C*, amputation of two toes with their metatarsal bones.

Amputation of toes with part of metatarsal bone is best done with the racket incision. The incision should begin on the dorsum of the bone to be removed just above the point of amputation. It should pass forward as far as the head of the bone, where it should divide into two arms passing forward and downward to either side of the base of the toe at the web. These two incisions continue as a transverse incision across the plantar surface of the toe at the level of the web (Fig. 1954, *A*).

The upper limb of the incision is deepened and the extensor tendons divided. In the case of the great toe or the little toe the tendons should be divided below the point of amputation far enough to allow the flexors and extensors to be sewed together or sewed to the periosteum of the stump. In the other toes the tendons may be cut short and allowed to retract. The incision is deepened to the bone and all of the soft structures removed from the bone. The ligaments connecting the head with the adjacent heads are divided. The two dorsal and the two plantar digital arteries are cut and tied.

The bone is best divided with a small circular saw or a wire saw. Beginning above the bone is lifted upward out of its bed. All cutting should be close to the bone. The plantar tissues should be protected. The wound is closed as a longitudinal incision.

Amputation of all toes with part of all metatarsal bones is done with a long plantar and short dorsal flap (Fig. 1955, *A*). The incisions begin and end at points on the inner and outer sides of the foot just above the saw line. In the adult foot, the dorsal flap should be marked out to extend about 2.5 cm. (1 inch) beyond the saw line and the plantar flap should be about 3 times the length of the dorsal flap. If the saw line falls in the middle of the meta-

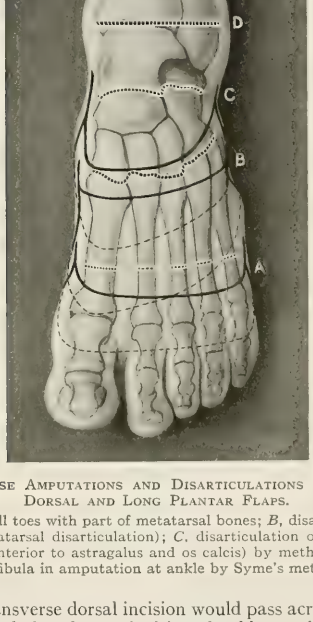


FIG. 1955.—TRANSVERSE AMPUTATIONS AND DISARTICULATIONS IN FOOT WITH SHORT DORSAL AND LONG PLANTAR FLAPS.

A, Amputation of all toes with part of metatarsal bones; *B*, disarticulation of all metatarsal bones (tarsometatarsal disarticulation); *C*, disarticulation of anterior part of foot at mediotarsal joint (anterior to astragalus and os calcis) by method of Chopart; *D*, line of section of tibia and fibula in amputation at ankle by Syme's method.

tarsal bones, the transverse dorsal incision would pass across the heads of the metatarsal bones and the plantar incision should pass just behind the web of the toes. The ankle should be strongly extended and the toes flexed on the foot while the dorsal incision is made, and flexed and the toes extended while the plantar incision is made.

The dorsal incision is deepened to the bone. The divided tendons should be caught so that they cannot retract beyond recovery. The flap is dissected up slightly above the saw line. The plantar flap is likewise turned back. The interosseous structures are cleared from the bones in the saw line, and the bones divided with a fine saw. The vessels to be tied are the

four dorsal interossei and the six plantar digital arteries. The extensor tendons are sutured to the flexors, the muscles are sewed over the bone-ends, and the flaps sutured.

Amputation of toe with whole of metatarsal bone is the same as the above except that instead of cutting through the bone it is disarticulated at the tarsometatarsal joint. The vertical incision should begin just above the upper end of the metatarsal bone (Fig. 1954, *B*). The disarticulation is accomplished through the dorsal wound. The plantar tissues should not be injured. Disarticulation is facilitated by first freeing the head of the metatarsal bone from connection with the two neighboring heads. The toe and bone can then be rotated and the tarsal ligaments cut. Because of its engagement between the internal and external cuneiform bones the second metatarsal bone is most difficult of disarticulation.

FIG. 1956.—AMPUTATIONS OF TOES AND FOOT (OUTER SIDE).

A, Disarticulation of little toe with its metatarsal bone; *B*, supramalleolar amputation by oblique incision; *B'*, supramalleolar division of bone; *C*, incision of Pirogoff for disarticulation at ankle; *C'*, oblique section of tibia and fibula in Pirogoff's amputation; *C''*, division of os calcis in Pirogoff's amputation; *D*, incision of Syme for disarticulation at ankle; *D'*, division of tibia and fibula in Syme's amputation; *E*, subastragaloid disarticulation of foot with heel flap.

In the case of the *great toe*, the upper end of the vertical incision should be prolonged well above the joint so that by wide retraction the joint may be freely exposed. Instead of this the upper end of the incision may begin at the joint and be joined by a short incision at right angles to it, passing along the inner side of the joint. Or the upper end of the vertical incision may curve inward to expose the inner side of the joint (Fig. 1951, *B*). This operation gives a very poor sort of foot. The surgeon should always plan to implant a piece of bone from elsewhere to take the place of the first metatarsal. A plastic operation should always be done, instead of an amputation, if possible. In all cases the insertion of the tibialis anticus and the peroneus longus should be preserved and sutured to the adjacent ligaments.

In the case of the *little toe* the upper end of the vertical incision may be continued as a curve to the outer side of the foot (Fig. 1956, *A*) to give better access to the tarsometatarsal joint.

Disarticulation of two or more adjacent toes with their metatarsal bones may be done with the racket incision or with plantar and dorsal flaps. In the case of two contiguous toes the racket incision is used. The operation is the same as for a single toe except that the longitudinal incision is placed between the two metatarsal bones (Fig. 1954, *C*). The upper end of the incision may be met by a short transverse cut to give better exposure of the tarsometatarsal joint. The longitudinal incision passes forward between the two bones as far as the heads where it divides, passes to the adjacent webs and includes the two toes to be removed. The same incision may be used for the removal of three toes, in which case the long incision lies over the middle of the three metatarsal bones. The steps of the operation are essentially the same as for one toe and its metatarsal bone.

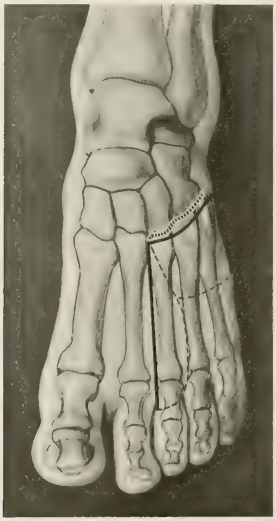


FIG. 1957.—DISARTICULATION OF OUTER THREE TOES AND METATARSAL BONES.

For the removal of more than two inner or outer metatarsals the long plantar and short dorsal flaps are to be preferred. Take for example the three outer. An incision begins over the tarsometatarso-metatarsal joint, between the second and third bones, and passes forward on the dorsum of the third metatarsal to its head, whence it curves inward to the web and thence back to the plantar surface of the same head, following the plantar line of the third metatarsal to a plantar point opposite the dorsal point of its beginning. The rest of the operation is by a long plantar and short dorsal flap marked out to cover the cuboid and external cuneiform bones (Fig. 1957). This same operation may be used for any one, two, three, or four inner or outer metatarsal bones and their toes.

Disarticulation of all the toes with their metatarsal bones is done with a long plantar and a short dorsal flap (Fig. 1955, *B*). This was formerly called *Lisfranc's operation.* The lines of incision terminate at the inner and outer sides of the foot at points just posterior to the tarsometatarsal joint. The inner point is the middle of the internal cuneiform bone, the outer is the tip of the base of the fifth metatarsal bone. The dorsal flap is cut by an incision beginning at one of these points and passing forward along the side of the foot about 2.5 cm. (1 inch), thence curving across the dorsum of the foot about 13 mm. (½ inch) below the line of the tarsometatarsal joint, it returns backward on the opposite side of the foot to the point of termination. The plantar flap is marked out by a U-shaped incision beginning and terminating at the same points as the dorsal incision; it passes forward on the border of the foot and then curves across the sole opposite the heads of the metatarsal bones, and returns to the point of termination on the opposite side. The transverse plantar part of the incision should pass somewhat farther forward on the inner aspect of the sole than on the outer, crossing at about the line of the first metatarsophalangeal joint and just behind the heads of the outer metatarsal bones. The inner side of the flap is made longer because of the greater thickness of the foot. The flap should be cut as broad as possible.

In making the dorsal incision the toes and foot should be bent downward, and in making the plantar incision they should be bent upward. The dorsal incision should be deepened to the bone; tendons and interosseous tissue should be dissected up close to the bones so as to include the vessels in the flap. This flap should be freed to a line just above the tarsometatarsal joint. The plantar incision should be deepened to the flexor tendons, and dissected back for 13 mm. (½ inch); then the tendons and other soft parts should be divided through to the bones. The soft tissues of the plantar flap are then dissected back to a line just back of the joint.

The joint is then disarticulated, the dorsal ligaments being first divided. This part of the operation is difficult unless the surgeon has in his mind a picture of the joint line. A narrow-bladed knife should be used, and held at right angles to the surface to be cut. In disarticulating the second metatarsal, the knife may be made to follow the line of the bone into the recess in the tarsus. Care should be taken not to injure the plantar flap. *Hey* advocated sawing off that part of the internal cuneiform which lies anterior to the middle cuneiform, and leaving it attached to the first metatarsal bone. This simplifies the operation.

The arteries to be tied in the dorsal flap are the four dorsal interosseous, and the communicating branch of the dorsalis pedis; in the plantar flap are the four plantar digital arteries, two terminal branches of dorsal communicating, internal plantar, or sometimes, the external plantar artery itself. The flexor and extensor tendons should be sewed together over the bones so as to appose one another. The dorsal and plantar flaps should then be sewed together. If the anterior tendons have been properly sewed to the front of the bones of the stump the balance between flexion and extension of the ankle-joint will be maintained. If there is a tendency to elevation of the heel and depression of the stump, the tendo Achillis should be divided.

Disarticulation of foot anterior to astragalus and os calcis (mediotarsal disarticulation) is at the astragaloscaphoid and calcaneocuboid joints. The operation as done by *Chopart* is carried out with a short dorsal and a long plantar flap (Fig. 1955, *C*). The dorsal incision begins at the outer side of the foot opposite the calcaneocuboid joint, passes forward and thence curves across the dorsum of the foot opposite the bases of the metatarsal bones.

The plantar incision begins at the dorsal incision just posterior to the tarso-metatarsal joint, passes forward and downward, and thence curves across the sole of the foot at the middle of the metatarsal bones, to return to the opposite side.

The dorsal incision should be deepened to the bone with the foot extended. The extensor tendons should be caught with a chromic catgut suture and divided distal to it. The flap containing all the soft tissues should be dissected back to a line above the joint. The same should be done with the plantar flap. It should be divided with the foot flexed upon the leg. The tendons should be caught with sutures of chromic catgut. The soft structures should be dissected free from the bone back to a line posterior to the joint. The ligaments of the joint should be divided as each is put on the

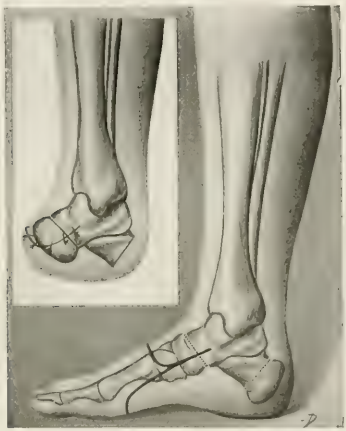


FIG. 1958.—MEDIOTARSAL AMPUTATION WITH ANTERIOR TRANSPLANTATION OF POSTERIOR PART OF OS CALCIS.

The posterior part of the os calcis is sawed off and fixed in front of the astragalus and os calcis. This operation removes redundant bone posteriorly and transfers it anteriorly where it is needed to give a better balanced stump.

stretch. The dorsalis pedis artery and its branches are to be ligated in the dorsal flap; and in the plantar flap, the external and internal plantar arteries and their branches.

The tendo Achillis should be divided. The flexor tendons should be sewed to the extensor tendons across the bony stump. The flaps should be sewed together. This leaves a poor sort of stump because of the backward projecting os calcis. There is a tendency for the heel to be displaced upward; or the tarsal bones may become inverted. The proportionate length of flaps may vary with the exigencies of the case.

Modification.—When this operation is contemplated, if time and the tissue conditions permit, I have been able to secure a better-balanced stump by transplanting the posterior part of the os calcis to the anterior face of the bony stump. The flap should be 13 mm. (½ inch) longer than described above. The anterior articular surfaces of the astragalus and os calcis are

destroyed by sawing them off evenly; and arthrodesis performed in the calcaneo-astragaloid joint. A longitudinal incision is made in the middle of the posterior aspect of the heel behind the tendo Achillis and the os calcis. This is dissected laterally to expose the tendon and the bone. The tendon is divided transversely at its insertion and the posterior part of the os calcis, representing about 1.3 or 2 cm. ($\frac{1}{2}$ or $\frac{3}{4}$ inch) is sawed off and transplanted to the front of the astragalus and os calcis (Fig. 1958). It should be made fast to the astragalus by a bone peg. It should take the place of the scaphoid and be located well internally to prevent inward rotation of the stump of the foot. The tendons are then sewed over it, and the flaps sutured in place. The object of this operation is to produce a better balanced arch by removing

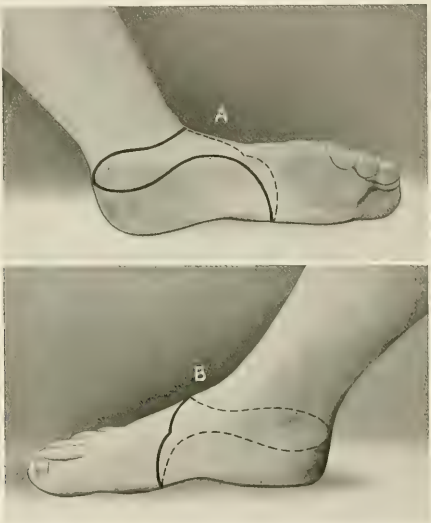


FIG. 1959.—SUBASTRAGALOID DISARTICULATION OF FOOT.
Incisions of Farabeuf. *A*, External and plantar incision; *B*, internal and dorsal incision.

some of the redundant posterior part and adding it to the shorter anterior part.

Subastragaloid disarticulation of foot may be done with a lateral flap, with a heel flap, with an oval flap, with anteroposterior flaps or such irregular flaps as the tissues provide.

The large *internoplantar flap* is the operation devised by *Farabeuf*. The flap is taken from the sole and inner aspect of the foot. The skin incision is begun at the outer margin of the tendo Achillis; it curves forward and upward to a point 1 inch (2.5 cm.) below the top of the outer malleolus; thence it passes forward, curving in a line parallel with the outer border of the foot to a point opposite the base of the fifth metatarsal bone whence it curves inward across the dorsum of the foot just anterior to the scaphoid bone as far

as the tendon of the extensor longus hallucis; at this point it changes direction and curves forward across the inner border of the foot at the base of the first metatarsal bone; and thence it passes across the sole, curves backward along the outer border of the foot, across the external tuberosity of the os calcis to the point of beginning (Fig. 1959).

This incision is deepened to the bone. The tendons are cut long. The outer portion of the flap is then dissected up until the tendo Achillis and the head of the astragalus are exposed. The tendon is divided. The knife is caused to enter the astragaloscaphoid joint on its dorsal aspect, and caused to cut downward, and thence backward between the astragalus and os calcis. The calcaneo-astragaloid ligaments are divided as far back as the posterior ligaments. This is done while the ligaments are put on the stretch.

The flap is then dissected free from the sole of the foot, keeping close to the bone. This dissection is continued around the heel and up the inner side of the os calcis. The internal ligaments are divided, and the disarticulation completed. This incision divides the posterior and anterior peritoneal, dorsalis pedis, and the internal and external plantar arteries. The opposing tendons should be sewed together. As the flaps are sutured, a drain should be left in the posterior end of the wound. This leaves a scar on the outer and anterior aspects of the stump.

The *heel flap* operation has much to recommend it. The incision begins 13 mm. (½ inch) below the tip of the external malleolus, and passes downward directly across the sole of the foot, and ends 2.5 cm. (1 inch) below the tip of the posterior border of the inner malleolus. The dorsal incision connects the upper ends of the plantar incision. It curves upward and forward across the dorsum on a level with the astragaloscaphoid joint (Fig. 1951, *E*).

After the skin flap has retracted the tendons are divided and the incision deepened to the bone. The dorsal flap is dissected up, and the plantar flap dissected free from the os calcis. The tendo Achillis is divided. The astragalus is freed from all of its distal attachments by dividing the tendons. The head of the astragalus may be sawed off. The external and internal plantar and the dorsalis pedis arteries require to be tied. The opposing tendons are sewed together. The heel flap is sutured to the dorsal flap. As the heel flap is tough, when it is bent forward it is held with some tension. The dressing should be so applied as to support it and take the strain from the sutures.

Modification.—The posterior part of the os calcis may be sawed off and left attached to the heel flap; the lower articular surface of the astragalus is sawed off; and as the heel flap is brought forward the piece of os calcis is brought in apposition with the astragalus (Fig. 1960).

Disarticulations at Ankle-joint.—The *anatomy* of the ankle-joint is peculiar. Its bones are the tibia, fibula and astragalus. The malleoli of the tibia and fibula project below the upper surface of the astragalus—the inner malleolus about 12 mm. (½ inch). The tip of the external malleolus is 1.2 to 2 cm. (½ to ¾ inch) lower than the internal, and occupies a plane about 13 mm. (½ inch) posterior to the internal. The ankle-joint is capable of flexion and extension, and slight lateral flexion and rotation. In front of the joint from within outward are the tibialis anticus, extensor proprius pollicis, anterior tibial vessels, anterior tibial nerve, extensor communis digitorum and peroneus tertius; behind, from within outward, tibialis posticus, flexor longus digitorum, posterior tibial vessels, posterior tibial nerve, flexor longus pollicis; and, in the groove behind the external malleolus, the tendons of the peroneus longus and brevis.

It is obvious that after disarticulation of the joint the two malleoli

project downward on either side as sharp points, and must either be removed or something must be interposed to occupy the space between them. It is customary to saw off the two malleoli after disarticulation. If possible it is better to leave the astragalus or as much of it as can be preserved. In some cases only the lower part of the astragalus need be sacrificed and the tips of the malleoli. In other cases not only must the malleoli be removed but also the articular surface of the tibia.

Cineplastic stumps may be made at the ankle, the flexor and extensor groups of muscles being used to move the artificial foot. A much more natural gait may thus be secured, and the degeneration of the muscles prevented.

Disarticulation of foot at ankle-joint with removal of malleoli is the most simple operation. It is best done with a flap taken from the heel. The dorsal incision begins at the tip of the external malleolus, passes forward

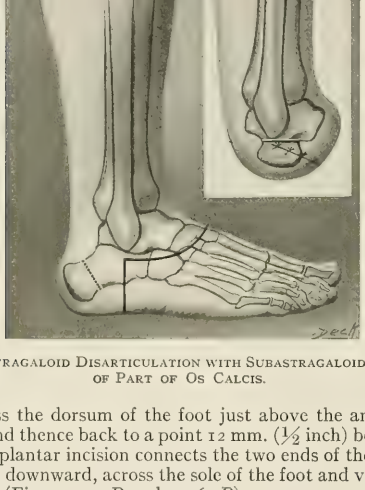


FIG. 1960.—SUBASTRAGALOID DISARTICULATION WITH SUBASTRAGALOID TRANSPLANTATION OF PART OF OS CALCIS.

and thence across the dorsum of the foot just above the anterior border of the astragalus, and thence back to a point 12 mm. (½ inch) below the internal malleolus. The plantar incision connects the two ends of the dorsal incision. It passes directly downward, across the sole of the foot and vertically upward to the other side (Figs. 1951, *D* and 1956, *D*).

The dorsal incision is made with the foot extended. It exposes the extensor tendons. These should be caught with sutures, each one separately, and the incision carried down to the bone. This incision should open the ankle-joint. The plantar incision, made with a strong sharp knife, sweeps across the sole of the foot and divides all of the soft tissues down to the bone. The heel flap should be dissected free from the os calcis, cutting close to the bone, as far as the tuberosity. The lateral ligaments are further divided through the dorsal incision. Then the posterior ligaments are divided and the foot is disarticulated. The tendo Achillis is finally cut. The foot is now drawn down and the skin dissected free from the rest of the os calcis.

The malleoli are then cleared of soft tissue and sawed off level with the horizontal articular surface of the tibia (Fig. 1955, *D*).

The anterior tibial, external and internal plantar, the external and internal malleolar branches of the anterior tibial, anterior peroneal, internal malleolar branch of the posterior tibial arteries are ligated; also the internal and external saphenous veins. The nerves should be cut short. The anterior tendons should be sutured to the posterior tendons across the end of the tibia. The heel flap should be brought forward and sutured to the dorsal flap by deep stitches. A small drain should emerge at each angle of the wound. The dressing should be so applied as to hold the tough heel flap forward so that it shall not make undue tension upon the suture line. *Syme*, in performing this operation, sawed off the tibia and fibula transversely about 6 mm. (¼ inch) above the articular plane of the tibia, thus removing all of the articular surface of the ankle-joint (Figs. 1951, *D* and 1956, *D*).

Disarticulation of foot at ankle-joint with preservation of posterior part of os calcis is carried out the same as the above operation, except that less of the malleoli is sacrificed and, in the dissection of the heel flap, in the posterior part of the os calcis is left attached to the soft tissues. Slightly larger flaps are made, the point of beginning of the incisions being just anterior to those of the above operation; and the anterior incision passes a little further forward on the dorsum of the foot. The Achillis is not cut. From 1.25 to 2 cm. (½ to ¾ inch) of the os calcis is preserved. The heel flap is dissected back leaving this much of the bone unexposed. It is sawed across parallel with the posterior surface (Fig. 1956, *C''*). The same length of the malleoli is left projecting below the articular plane of the tibia; the rest is sawed off. The articular synovial surface of the tibia is destroyed by a sharp curet. The soft tissues are sutured in such a way as to hold the bone fragment in place. If necessary a bone peg may hold the fragment. The flexor tendons are sutured across the stump to the extensor tendons. In children before puberty, the epiphysis for the posterior tuberosity of the os calcis has not yet united with the body of the bone, and at this age this operation should be preferred.

This is the best operation for disarticulation at the ankle-joint. If the synovial surface is destroyed and the piece of os calcis is held by a bone pin and suturing of the soft parts, osseous union will be secured; and a strong stump results.

This operation, as devised by *Pirogoff*, frees the plantar flap back as far as the tuberosity of the os calcis; disarticulation is accomplished as above; and the posterior part of the os calcis is sawed from above downward with the foot extended and the soft parts retracted. The lower part of the tibia and fibula are then freed and sawed off, as was done by Syme, except that the saw enters anteriorly about 6 mm. (¼ inch) above the lower border of the tibia and emerges posteriorly about 1.25 cm. (½ inch) above the posterior articular border. This is to conform to the obliquity of section of the os calcis.

The os calcis may be sawed vertically and the tibia and fibula horizontally. By leaving the bone attached with the tendo Achillis better nourishment of the heel flap is guaranteed. If the bone does not unite no harm is done if it has been well fixed in position.

Amputations of the Leg.—These amputations are done between the ankle-joint and the knee-joint. They should be carried out with especial reference to providing a stump which is capable of bearing the weight of the body.

For descriptions of the *Surgical Anatomy* of the Bones of the Leg, see Fractures, Vol. I, page 472; for Vessels, see Vessels, Vol. I, page 437. But two bones are involved, the

tibia and fibula (Fig. 1961). The fibula is behind and internal to the tibia. The tibia at its lower third has no muscles attached to it. The bones are everywhere covered by muscles or tendons except at their upper and lower extremities, the inner surface of the tibia, and the lower part of the external surface of the fibula. The nerve supply is from the lumbar and sacral plexuses. The skin of the inner side of the leg is supplied by the internal saphenous; the outer side by the communicans peronei, the external saphenous, and external popliteal; the front by the internal saphenous and external popliteal above and the musculocutaneous below; and the back by the internal and external saphenous nerves.

The tibialis anticus is the large muscle on the front of the leg lying external the tibia. External to this lies the extensor longus digitorum. The three peronei lie externally. The fleshy mass of the calf is formed largely by the tibialis posticus, flexor longus, gastrocnemius, and soleus. The two latter end in the tendo Achillis. Tendons predominate in the lower third of the leg. The popliteal artery usually divides 5 cm. (2 inches) below the knee-joint, at the level of the lower border of the tubercle of the tibia into anterior and pos-

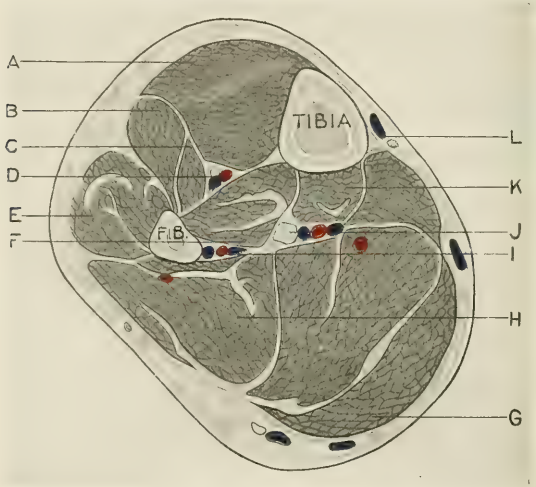


FIG. 1961.—CROSS-SECTION AT MIDDLE OF RIGHT LEG.

A, Tibialis anticus; *B*, extensor longus digitorum; *C*, extensor pollicis; *D*, anterior tibial artery, vein and nerve; *E*, peronei; *F*, tibialis posticus; *G*, gastrocnemius; *H*, soleus; *I*, peroneal artery and veins; *J*, posterior tibial artery, veins, and nerve; *K*, flexor longus digitorum; *L*, long internal saphenous vein and nerve.

terior tibial. The peroneal branch of the posterior tibial comes off about 2.5 cm. (1 inch) below the lower border of the popliteus muscle. The lower border of the popliteus is on a level with the lower border of the tubercle of the tibia. Thus, amputation within 5 cm. (2 inches) of the knee-joint divides one great artery; amputation between 5 and 7.5 cm. (2 and 1/3 inches) below the joint divides two arteries; and amputation beyond 7.5 cm. (3 inches) divides three.

Certain *general principles* should be observed. Tendons and muscles should be saved as much as possible. The anterior muscles or tendons should be sewed to the posterior muscles or tendons across the ends of the bones in order to preserve the natural antagonism of the muscles and thus prevent their degeneration. Cineplastic amputations should be made whenever practicable.

In all amputations of the lower extremities it is best to have the limb project beyond the table, thus rendering all parts easily accessible.

Care should be taken not to injure the anterior tibial artery above the point where it must be cut at the lower limit of the flap. The surgeon should know accurately the location of the larger nerve trunks. They should be cut but once. When they are exposed, in cutting the flaps, they should be drawn down before they are divided, and cut at a higher level than the other tissues.

Amputation with a posterior flap is generally preferred where it is desired to secure a thick padding for the stump because of the heavy posterior muscle mass. In the lower third of the leg anteriorly there are no muscles. The fibula is apt to be drawn out of position in high amputations so it should be sawed higher than the tibia. The ordinary artificial legs do not press upon the end of the stump but upon the bony prominences at the knee. The stump therefore has value for leverage. Properly constructed stumps should be capable of end-bearing and artificial legs should be made accordingly. There are objections to an end scar.

Cineplastic stumps can be made in the leg. The same principles are employed as in the arm. By utilizing tendons and muscles for motile purposes the muscles are kept alive, the health of the stump is more vigorous and movements of the foot at the ankle may be controlled by will. A motor stump may be made from both the anterior and posterior group of muscles. A cord from each should be carried to the artificial foot, thus giving muscular control of both flexion and extension at the ankle. Or the anterior or posterior group alone may be used and the antagonistic action accomplished by springs (see Cineplastic Amputations, page 526).

Osteoplastic amputations of the leg have been described (page 524).

Supramalleolar amputation is similar to the operations for disarticulation. It is done with a heel flap (Fig. 1956, *B*). The incision begins in front of the ankle-joint, passes downward and backward along the anterior border of the malleolus, to the extreme postero-inferior aspect of the heel, and thence upward and forward on the opposite side to the point of beginning. This is the incision of *Guyon*. It may be made perfectly straight or slightly curved. This incision is carried down to the bone. The joint is not opened. The soft parts are dissected back close to the bone for about 5 cm. (2 inches) above the tips of the malleoli, where the bones are sawed (Fig. 1956, *B'*). The tendo Achillis is divided at its insertion, brought forward across the bone ends and sutured to the anterior tendons. The heel flap is brought forward and sewed to the concave anterior skin edge.

Amputation through lower third of leg is commonly done by a *long posterior flap*. This flap is taken more from the postero-internal aspect than from the posterior. The saw line having been determined, the incision on the inner side begins at the saw line on the inner side of the tibia, and passes vertically downward for a distance equal to about $1\frac{1}{4}$ diameters of the limb at the saw line. It then curves backward, passes across the back of the leg and forward on the opposite side to a corresponding point. The anterior incision begins at the vertical incision, one-fourth the distance from its upper end, curving sharply forward and slightly downward, passes halfway round the leg, to join the same incision on the opposite side. The operation produces a *short anterior* and a *long posterior flap*. This is called the incision of *Farabeuf*. The first incisions pass through skin and fascia. They are then deepened to the bone with a strong knife cutting at the border of the retracted skin. The flaps are dissected up to a level just above the saw line. The soft parts are retracted and the bones divided. The sharp anterior border of

the tibia is beveled. The vessels are tied. The posterior muscle mass is brought forward and sewed to the anterior muscles. The posterior flap is sewed to the anterior. The stump should be dressed and put upon a posterior splint.

Amputation by an *oblique circular incision* secures all of the flap from the back of the leg and fits its convexity into an anterior concavity (Fig. 1963, *A*).

Amputation through middle third of leg is done by a *long posterior flap* just as for the lower third. It is called the *operation of Hey*. In both of these operations there is a short anterior flap. The breadth of each flap is equal to half of the circumference of the limb at the saw line. The length of the posterior flap is equal to the

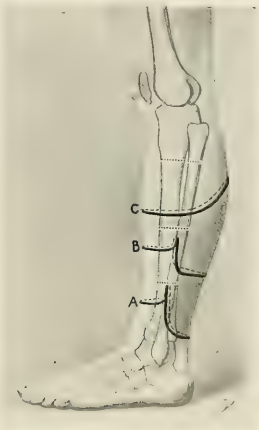


Fig. 1962.

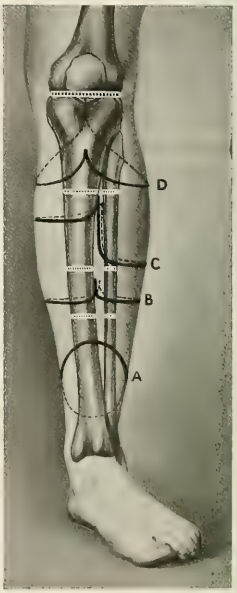


Fig. 1963.

Fig. 1962.—Amputations of the Leg.

A, Amputation in lower third by long posterior and short anterior flaps; *B*, amputation in middle third by long posterior and short anterior flaps; *C*, amputation in upper third by lateral flaps (hooded flap of Stephen Smith).

Fig. 1963.—Amputations of the Leg, Anterior Aspect.

A, Oblique circular incision; *B*, equal lateral flaps (modified circular amputation); *C*, long external and short internal flaps; *D*, bilateral flaps (hooded flap operation of Stephen Smith).

diameter of the limb at the saw line. The vertical incision begins 2.5 cm. (1 inch) below the saw line. The inner incision follows the inner border of the tibia. The outer incision lies just behind the fibula. The two vertical limbs are united by the transverse vertical incision which curves into them, forming a U. This whole incision is made with either one or two sweeps of the knife. The anterior flap is one-third the length of the posterior flap. It is made by joining the two vertical limbs by an anterior transverse incision, inclined slightly downward. This operation forms a

long posterior and a *short anterior flap*. It is a double flap operation (Figs. 1962 and 1967). These incisions should pass only through the skin and fascia. The muscles are divided in the line of the retracted edges of the flaps. This should be done with a sharp strong knife. The soft tissues are then dissected up from the bones for a distance above the saw line far enough to permit sawing of the bones without injury to the flaps. The vessels are tied. The posterior muscles are sewed across the bone-ends to the anterior muscles. The skin flaps are sutured, and the limb dressed and put up on a posterior splint.

Amputation in the middle third may be done by *equal lateral flaps*. This is a modified circular amputation (Fig. 1963, *B*).

Amputation through upper third of leg may be done by a *long posterior* and a *short anterior flap* (*Hey*). Amputation by a *long external* and a *short internal flap* (*Farabeuf*) is often most useful (Fig. 1963, *C*). The best operation is with lateral flaps (*Stephen Smith*). Such amputations should be done below the tubercle of the tibia, and the stump should be watched during the course of healing to prevent flexion. If care is not taken the stump becomes flexed at a right angle and the result is not as good as that secured by disarticulation at the knee. If flexion of the stump is progressing and can not be overcome, the hamstring tendons should be cut. Some surgeons perform this tenotomy at the time of amputation, in anticipation of the flexion.

The *operation with bilateral flaps* begins with a skin incision starting behind at the level of the saw line; it curves downward and forward to a point on the crest of the tibia a distance below the saw line equal to one-fourth of the circumference of the limb at the saw line or three-fourths of the diameter at the saw line (Fig. 1962, *C*). The same incision is duplicated on the other side of the limb. This whole incision is made with one or two sweeps of the knife as follows: The surgeon grasps the limb with the left hand, marking the posterior limit of the incision with the left index-finger and the anterior limit with the thumb; the knife is entered at the upper posterior limit and carried across the side opposite the surgeon; it may then be continued with its back toward the surgeon on the near side of the limb back to the point of starting; or it may be removed and the last half of the incision made from the back of the leg forward the same as the first half. Some surgeons begin by grasping the knife in the fist, applying it at the skin with the point directed toward the surgeon, carrying the incision on the opposite side of the leg upward and backward, and thence sweeping across the near side downward and forward to the shin, thus completing the incision with one stroke. Making the incision with two deliberate strokes, one on either side, is better.

The skin and fascia are divided by the first incisions. The flap is dissected up for about 2.5 cm. (1 inch) from its lower border, retracted and the muscles divided down to the bone by a horizontal circular incision. The muscle is retracted upward, and the bones sawed. The fibula should be sawed shorter than the tibia, and the skin angle should be bevelled. Some surgeons remove the fibula entirely, disarticulating it from the tibia. The vessels should be tied. The muscle is quilted over the stump, and the skin flap sutured over all. The longitudinal antero-posterior scar which results draws backward away from the end of the stump.

The *operation with equal lateral flaps* is applicable to any part of the leg but is used especially in the upper third. It is similar to a circular amputation with the addition of an anterior and posterior vertical incision. Two equilateral flaps are made. Their lower limit should be below the level of the saw line a distance equal to three-fourths of the diameter of the leg at the

saw line. The flaps are marked out by an incision beginning anteriorly just to the outer side of the crest of the tibia and just below the level of the saw line. It passes downward and curves across the side of the leg to the midposterior surface where it turns upward, to end opposite the point of beginning. This is joined by a second incision passing about the other side of the leg and marking out the other flap (Figs. 1963, *B* and 1966, *A*). The muscle is cut to the bone at the level of these flaps. It is retracted, and the bones divided. The muscles are sewed over the bone-ends, and the skin sutured over all. An end scar results.

The *operation with a large external flap* is begun by an incision beginning at the level of the saw line anteriorly, passing directly downward just internal to the anterior border of the tibia. It curves outward and backward across the outer side of the leg, and then curves directly upward on the posterior aspect to end about 2.5 cm. (1 inch) below the level of the saw line, marking out a flap having a length equal to one-third of the circumference of the limb at the saw line. The internal incision passes transversely across the inner side of the leg with a slightly downward curve joining the first incision anteriorly and posteriorly about 4 cm. (1½ inches) below the saw line (Fig. 1963, *C*). The external incision is then deepened along the line of the retracted skin, and the muscles divided to the bone. The anterior vertical incision is deepened close to the tibia, and the muscles separated from the outer surface of that bone, from the interosseous membrane, and from the fibula. The deeper structures are similarly divided on the inner side. In dissecting up the muscle masses from the bone and interosseous membrane care should be taken not to injure the anterior tibial artery above the point at which it is cut across at the lower limit of the flap lest the nourishment of the flap be impaired. This accident should be guarded against both anteriorly and posteriorly. The anterior tibial artery pierces the interosseous membrane at the level of the lower border of the tubercle of the tibia. It may be injured posteriorly in attempting to clear the muscle too high from the interosseous membrane. The soft parts are retracted upward and the bones sawed, the fibula a little higher than the tibia. The crest of the tibia is bevelled. The vessels are tied. The nerves should be drawn down and cut off when the flaps are being cut. The muscles are quilted across the bone ends, and the long flap sewed to the short flap. The limb should be dressed and put on a posterior splint.

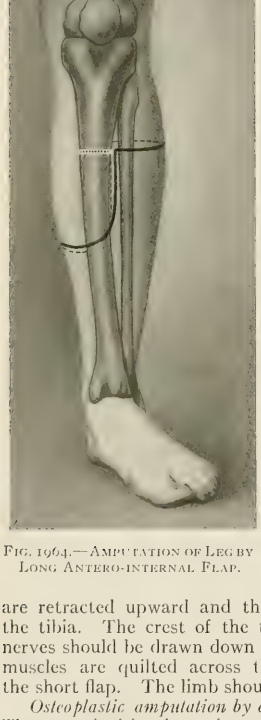


FIG. 1964.—AMPUTATION OF LEG BY LONG ANTERO-INTERNAL FLAP.

Osteoplastic amputation by antero-internal flap was recommended by Bier. The same incision is made as for the above operation except that the long flap is directed forward and inward. No small flap on the opposite side is made; the horizontal incision comes off at right angles from the upper limits

of the interior incision, at the level of the saw line. The base of the large flap has a breadth equal to half the circumference of the limb. The length of the flap should be slightly greater than the diameter of the leg at the level of the saw line (Fig. 1964). These flaps should be marked out by incisions passing through skin and fascia, and the flap dissected back. The periosteum is incised transversely across the inner surface of the tibia at the lower level of the flap. This periosteal incision is joined at either end by a vertical incision each lying close to the border of that surface. The bone flap is cut and turned across to the fibula, as described on page 524. The muscle having been largely sacrificed, the skin flap is sewed across the stump.

The defect of this operation is that the muscle is sacrificed. When an osteoplastic operation is done it is better to use one of the operations which preserve more muscle for the flaps.

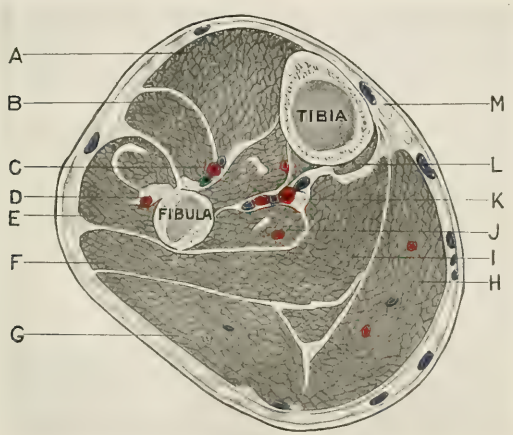


FIG. 1965.—CROSS-SECTION AT UPPER THIRD OF RIGHT LEG.

A, Tibialis anticus; *B*, extensor longus digitorum; *C*, anterior tibial vessels and nerve; *D*, musculocutaneous nerve; *E*, peroneus longus; *F*, *G*, *H*, *I*, gastrocnemius; *J*, soleus; *K*, posterior tibial vessels and nerve; *L*, popliteus; *M*, internal saphenous nerve and vein.

Comment.—In amputating through the leg, any of the many incisions or forms of flaps may be used. The operations which have been described for any third of the leg may be employed in either of the other thirds. The simple circular and the modified circular operations may be used. The surgeon must be governed by the exigencies of each case.

Osteoplastic operations, whereby a bridge of bone is thrown across to connect the two bones, may be used at any part of the leg where the two shafts are divided.

Cineplastic operations are to be done whenever possible.

Disarticulation at Knee-joint.—For the *anatomy* of the knee-joint, see Joints (Vol. I, page 688), and Resections (Vol. I, page 749). For vessels, see Popliteal Artery (Vol. I, page 437). The important anatomical structures to be observed in disarticulation are the femur above, the tibia and fibula

below, the patella in front, and the popliteal vessels and nerves behind (Fig. 1965).

The line of the knee-joint may easily be made out by flexing the joint, when the inner tuberosity of the tibia will press inward under the skin and its upper edge can be distinguished. The depression between the outer condyle of the femur and the tibia can be felt. The lower level of the synovial membrane of the joint is at the upper level of the tibia. The prominent part of the tubercle of the tibia is 2 cm. (¾ inch) below the upper articular surface of the tibia. The upper border of the tubercle is on a level with the upper limit of the fibula. In the extended position the lower point of the patella is on a level with the upper margin of the tibia.

The upper surface of the tibia is horizontal; the shaft of the femur inclines downward and inward from the pelvis to the knee-joint; the shaft of the tibia is vertical; therefore the inner condyle of the femur is longer than the outer condyle. The synovial membrane extends 7.5 cm. (3 inches) above the tibia on the antero-internal aspect of the thigh.

The upper epiphysis of the tibia and the lower epiphysis of the femur unite to their respective shafts about the twentieth year. The upper epiphysis of the fibula unites about the twenty-fifth year. The longitudinal growth of the lower extremities is chiefly from the lower epiphysis of the femur and the upper epiphysis of the tibia. The capsular ligament of the joint is attached above the epiphyseal line of the femur.

The popliteal structures which are palpable are the two hamstring tendons. The outer one is made up of iliotibial band and biceps tendon; the inner is composed of the tendons of the semimembranosus, semitendinosus, gracilis, and sartorius muscles. The external popliteal nerve lies close to the outer hamstring.

The *general principles* of disarticulation at the knee are the same as for other joints. This operation secures a stump which is much better than that resulting from amputations through the thigh. The rounded knob-like end of the femur provides an excellent bearing surface and provides a stump-end which can be used directly to sustain the weight of the body. Although the knee-joint of the artificial leg must be lower than that of the natural leg disarticulation is preferable to amputation above the knee.

The patella should not be removed. The semilunar cartilages should be separated from the tibia and retained attached to the femur. They contribute to form the cushion for the bearing surface. The patellar tendon should be detached from the tibia and sewed to the hamstring tendons.

The patient lies supine with the leg projecting over the edge of the table. The leg is held horizontally while the skin incision is made, and vertically while the flaps are dissected back. The prone position offers some decided advantages.

The cinematic stump may be made at the knee to a great advantage. An artificial leg may be constructed with muscular control of flexion and extension of the knee, and also with control of the ankle-joint. The loop or "button-hole" for the motor cord must be deep and strongly made. A separate group of muscles should connect with the foot. The vasti and rectus may operate on the knee and the sartorius on the foot anteriorly. Posteriorly the hamstring muscles may flex the knee, and the adductor longus extend the foot. Each case must be worked out as a separate problem.

Disarticulation at the knee-joint by bilateral flaps is the operation devised by Stephen Smith. Hooded flaps are made as follows: The incision begins in the middle of the popliteal space opposite the joint line, and passes downward for about 5 cm. (2 inches), thence it curves outward and downward to the outer side of the leg to about 5 cm. (2 inches) below the level of the tubercle of the tibia, and thence upward and forward to a point on the anterior aspect of the leg about 2.5 cm. (1 inch) below the tubercle. This marks out the external flap. The internal flap is marked out to correspond with the external flap except that it should be slightly longer to cover the longer internal condyle (Fig. 1963, *D*).

This flap of skin and connective tissue should be dissected up for about

2.5 cm. (1 inch) above its lower border, that is to the level of the anterior end of the incisions which is 2.5 cm. (1 inch) below the tubercle of the tibia. At this level the flaps are retracted upward and a circular incision through all of the soft parts carried down to the bones. These soft tissues are then elevated as close to the bones as possible, the patellar ligament is separated from its tibial insertion, the lower attachments of the capsular ligament and the semicircular cartilages attached to them are separated from their bony connections. The joint is thus opened. The semilunar cartilages are detached with the joint extended, the joint is flexed, and the crucial ligaments are cut, and the disarticulation completed. The synovial membrane is left lining the flap.

Ligation of the popliteal artery and vein, the sural, superior articular and anastomotica magna arteries is necessary. The muscles and deep fascia are quilted across the lower end of the femur. The patellar ligament is sewed to the hamstring tendons. The patella is left lying in front of the femur. The skin-flap is sutured, leaving an anteroposterior scar line, higher behind than in front. A drain should be left in. The tendency of the scar is to become still further displaced backward.

This operation is often carried out by simply dissecting the skin-fascia flap up to the joint and then disarticulating squarely across the joint line, thus leaving only this flap for a covering. Although only skin and fascia cover the bone a good result is secured.

Disarticulation of the knee-joint by unequal anteroposterior flaps should be by a long anterior or a long posterior flap. By making one flap 4 times the length of the other the scar falls posteriorly or anteriorly and not transversely across the bearing surface as is the case when the flaps are of equal length. The principles of this operation are the same as described for amputations (page 520) so far as the dissection of the flaps is concerned. The treatment of the deeper structures is as described for disarticulation with bilateral flaps.

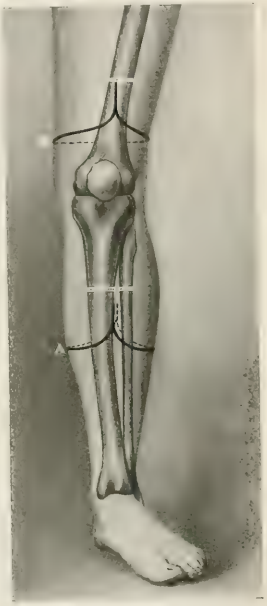


FIG. 1966.—AMPUTATIONS ABOVE AND BELOW KNEE.

A, Amputation of leg with lateral flaps; *B*, amputation of lower third of thigh by the racket incision.

Disarticulation of the knee-joint by a single long flap is carried out the same as for amputation so far as the skin-fascia flap is concerned (page 519). The flap may be anterior, posterior, lateral, or any combination of these. The treatment of the deeper structures is the same as in disarticulation by bilateral flaps.

Disarticulation of the knee-joint by an oblique incision (elliptical method) is carried out the same as for amputation so far as the skin-fascia flap is concerned (page 521). A long anterior flap is made. The incision begins posteriorly at the level of the joint line, and curves downward and forward to a point on the front of the leg 8 cm. (3 inches) below the tubercle of the tibia.

The other half of the incision is the same (Fig. 1967, *B*). The skin incision is carried out the same as amputation by this method. The treatment of the deep parts is the same as for disarticulation with bilateral flaps. The long anterior flap is turned backward and caused to fill the posterior notch.

Amputations of the Thigh.—For the *anatomy* of the thigh, see Fractures (Vol. I, page 583), and Vessels (Vol. I, pages 429 and 431). The great muscles almost cover the bone; it is subcutaneous only at the great trochanter and the condyles.

The cutaneous nerves in front are the ilio-inguinal; genitocrural; external, middle, and internal cutaneous; and behind, the small sciatic. The great sciatic nerve, which supplies the muscles of the back of the thigh, is nearly 2 cm. (¾ inch) broad. It passes out of the pelvis through the great sacrosciatic foramen below the pyriformis muscle, descends between the tuberosity of the ischium and the greater trochanter along the back of the thigh to about its lower third where it divides into the internal and external popliteal nerves. It rests at first upon the external rotator muscles and is covered by the gluteus maximus; lower down it lies on the adductor magnus and is covered by the long head of the biceps. The internal popliteal is a continuation downward of the main nerve and is the larger of the two terminal branches.

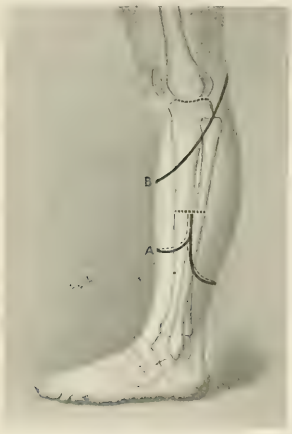


FIG. 1967.—AMPUTATIONS ABOUT THE KNEE.

A, Amputation of leg by long posterior and short anterior flap; *B*, disarticulation of knee by oblique oval flap.

The shaft of the femur is nearest the external aspect of the thigh in its upper third and nearest the anterior aspect in its lower third. In the middle it is almost evenly surrounded by muscle. The superficial layer of the deep fascia forms a dense capsule, covering the muscles, and sending off septa between the muscles and to the linea aspera. The muscles vary in length. Most of them are attached to the femur. The muscles which end in the hamstring tendons, except the biceps, are not attached to the femur. The farther from its attachments a muscle is divided the greater is the retraction. For this reason the muscular retraction in thigh stumps is irregular. The lower the amputation the greater the retraction. The most retraction is on the back of the stump and internally.

The adductor tubercle is the point of attachment of the adductor longus muscle; it is located at the extreme lower end of the branch of the linea aspera which runs to the inner condyle; and is situated at the inner and posterior aspect of the condyle, on a level with the upper limit of the articular cartilage.

The medullary canal is distinct only in the middle two-fourths of the femur. The lower epiphyseal line is on a level with the adductor tubercle and with the upper limit of the articular cartilage. The lower epiphysis unites with the shaft about the twentieth year. The head of the femur and the great trochanter join the shaft at the eighteenth year.

The *general principles* of amputations of the thigh are the same as for the leg or arm. Primary hemostasis is most important because of the great thickness of the part. In the young, amputation below the epiphyseal line is desirable. In all cases as much of the femur as possible should be saved. Even a short stump is to be preferred to disarticulation at the hip. Subtrochanteric amputation is better than disarticulation at the hip. Although the weight is not borne on the stump, the longer the stump is the better is the leverage for the operation of an artificial limb. Weight usually is born on the ischium and sides of the stump. Amputation

through the condyles gives a stump the end of which can bear the pressure of the body; amputation of the shaft usually does not. The patella should be saved in all amputations in which the muscles above it do not have to be sacrificed. The higher the amputation the greater the shock. This is an important fact. In all thigh amputations shock is a serious matter, and every means to prevent it should be employed. An ordinary rubber tourniquet, around the thigh just below the hip-joint, is used to control hemorrhage in amputations through the lower or middle thirds. In higher amputations the tourniquet should be applied as a spica or figure-of-eight thrown around the thigh and pelvis (see Control of Hemorrhage). The large nerves should be divided but once, and then drawn well down and divided high. The sciatic nerve should be injected with anesthetic before division.

The usually preferred method of amputation through the thigh is by a long anterior and a short posterior flap. The femoral and profunda arteries will be in the anterior flap in amputations in which anteroposterior flaps are cut above the center of the thigh; and in amputations in which these flaps are cut below the center of the thigh these vessels will lie in the posterior flap. In amputations in the middle of the thigh the flaps should be cut not anteroposteriorly but shifted internally or externally so as not to split the femoral artery.

It is best to mark out the skin incision with a scalpel rather than to amputate by transfixion. The incision is then deepened through the muscles. The large nerves should be identified before they are cut; they should be drawn down and cut high above the level of the incision across the muscle. Only in emergencies when haste is the essential, is amputation by transfixion in the upper two-thirds of the thigh to be recommended. Circular amputation is the quickest in the lower third.

The soft parts should be retracted and the femur sawed squarely across. No spicule of bone should be left projecting below the saw-line. The bone should be sawed on a line at right angles to the long axis of the limb, not at right angles to the long axis of the femur. The muscles should be sewed across the end of the bone, and the skin flaps sutured over all.

Osteoplastic amputation is of advantage in giving the sawed bone end a covering with bone which has periosteum. The transplanted bone may be taken from the patella, tibia or from the femur itself.

The cineplastic stump may be made in the thigh and muscles preserved to flex and extend the artificial knee-joint. The loop or "button-hole" for the motor cord should be deeply placed and strong. It should be well reinforced with tendon or fascia.

Amputation through the condyles may be done with a long posterior flap, a long anterior flap or by any of the forms of flap used in disarticulation at the knee-joint.

When done *with a long posterior and a short anterior flap* the incisions begin above on the outer and inner sides of the condyles just below the saw line. The saw line is transverse and passes through the condyles just above the intercondyloid notch, removing the lower half of the condyles. The lateral incisions pass downward to the level of the joint line where they divide. The anterior flap is marked out by the incision continuing downward and forward crossing the front of the knee just above the tubercle of the tibia. The posterior incision leaves the same line at the level of the joint and passes downward and backward crossing the back of the calf a little below the level of the tubercle of the tibia (Fig. 1968, *A*).

The incisions pass through skin and superficial fascia. The posterior incision is then deepened, at the line of skin retraction, through the soft

tissues down to the bone. The divided structures, together with the ligaments of the joint, are dissected upward as far as the saw line. The anterior incision is retracted downward and the patellar ligament is divided at its insertion into the tibia; the incision is then carried down to the bone, and the flap dissected up. This anterior flap includes the ligamentum patellæ, the ligaments of the joint, the patella, and all of the soft tissues anterior to the joint. The flap should be turned upward and the condyles freed as far up as the saw line. The condyles are grasped by heavy lion-jawed forceps and sawed across at right angles to the long axis of the thigh.

FIG. 1968.—AMPUTATIONS OF THIGH.

A, Transcondyloid amputation of thigh by long posterior and short anterior flaps; *B*, supracondyloid amputation by long anterior and short posterior flaps; *C*, amputation of shaft by long anterior and short posterior flaps.

The anterior flap remaining everted, a knife is passed along the upper border of the patella posteriorly, dividing the quadriceps tendon. This permits the patella to be drawn downward when traction is made on the ligamentum patellæ. The bone is grasped with forceps and its articular surface sawed off, although this step in the operation may well be omitted. The patella is then placed against the cut surface of the femur. If the patella is not sawed, its articular surface is placed against the cut femur. It may be fixed there by a pin. The best sort of pin is made by chiseling a sliver of bone from the tibia or fibula about 2.5 cm. (1 inch) long, and driving it in a hole bored through the center of the patella. The ligamentum patellæ is sutured to the ligamentous structures posterior to the joint. The muscular structures of the posterior flap are brought forward and sewed across the bone, and the skin flaps united.

Osteoplastic amputation through the condyles may use the patella, as described above, or a section of the tibia may be transplanted. The latter method was devised by Ssabanajeff. In this operation, a long anterior and a short posterior flap is cut (Fig. 1969). The posterior flap should be half the length of the anterior. The posterior flap alone of skin and superficial fascia is dissected up to the saw line. The incision is then carried down to the joint posteriorly. The posterior, lateral, and crucial ligaments are divided. The leg is then bent forward so that the front of the leg lies on the front of the thigh. The condyles of the femur are then sawed through transversely and the lower segment of the condyloid expansion removed. A bone flap having a thickness about the same as that of the removed condyles, is then taken from the anterior and upper part of the tibia. This is made by sawing downward from the upper articular surface of the tibia to the level of a point below the insertion of the patellar ligament. The limb is then turned downward, and through the anterior incision, the tibia is sawed transversely below the tubercle, thus detaching a segment of bone.

This segment of tibia is left attached to the anterior flap. The insertion of the patellar ligament into this piece of bone is retained (Fig. 1969). The anterior flap is then turned back, the piece of tibia is fixed to the femur by suturing the surrounding ligaments, and the soft flaps united (Fig. 1970).

Supracondyloid amputation of the thigh may be done with anterior and posterior flaps or with lateral flaps such as used in disarticulation of the knee.

When done with a *long anterior* and a *short posterior flap*, if the femur is divided just above the condyles, at the level of the adductor tubercle, and the patella is applied to the sawed end of the femur, a good weight-bearing stump is secured. The upper ends of the incisions laterally are at the level of

FIG. 1969.

FIG. 1969.—TRANSCONDYLOID AMPUTATION AT KNEE.

Showing long anterior and short posterior flap and method of cutting the bone. The lower end of the femur is removed, and in its place is fixed a section sawed from the front of the tibia.

FIG. 1970.

FIG. 1970.—RESULT AFTER TRANSCONDYLOID OSTEOPLASTIC AMPUTATION AT THE KNEE.

the saw line. The anterior flap is marked out by an incision which crosses the front of the knee about 2.5 cm. (1 inch) below the tubercle of the tibia. The posterior flap is about one-third the length of the anterior flap; its lower border is on a level with the upper end of the tibia (Fig. 1968, *B*).

The flaps having been marked out by incisions passing through the skin and superficial fascia, the incision is deepened to the bone along the line of retraction. The patellar ligament is divided at its tibial attachment. The ligaments of the joint are dissected back with the flaps. The bone is sawed transversely to the long axis of the limb. The vessels are tied. The articular surface of the patella is removed with a thin saw, or it may be left, and the patella is applied with its posterior surface upward to the sawed femur.

It may be fixed in place by suturing the patellar ligaments to the capsular ligament remaining in the flaps, or with a bone pin. The capsular ligaments are sewed across the end of the stump, and the skin over all.

Supracondyloid amputation may be done higher than the above described operation. A favorite site is 2.5 cm. (1 inch) above the condyles, in which case the flaps are made 2.5 cm. (1 inch) shorter. This operation has the advantage that the patella falls easily across the end of the sawed femur without tension and the quadriceps tendon need not be cut.

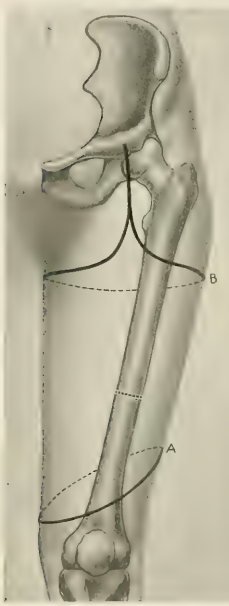


FIG. 1972.—AMPUTATIONS OF THIGH.

A, Amputation by elliptical incision; *B*, disarticulation at hip-joint by anterior racket incision.

Thigh amputations through the shaft of the femur may be done by the oblique circular method, by long anterior and short posterior flaps, by the circular method, by equal anterior and posterior flaps, by the racket incision, or by any of the methods described for the other extremities. Unequal flaps from the sides or other parts may be used. Osteoplastic covering of the end of the sawed femur is always desirable. For transplantation for this purpose the patella, tibia, or femur furnishes bone (see Osteoplastic Amputations, page 524).

In *amputation through the lower third of the thigh*, the *elliptical incision* is of advantage. The lower part of the incision is usually placed at the postero-internal aspect of the thigh, and the upper part is placed at the antero-external aspect, although its position may vary with the condition of the tissues. The upper limit of the incision should be a little more than half of the diameter of the limb below the saw line. The lower limit of the incision should be a little less than one diameter of the limb below the saw line. These two diameters should be calculated as at the level of the saw line. This provides a flap having a length of three-fourths of the diameter of the leg (Fig. 1972, *A*). This incision is carried down to the muscle. The next incision passes through the outer half of the muscles and is made at the level of the retracted skin flap. The divided superficial muscle retracts, and the final incision is made at the level of the retracted muscle of the flap. This passes down to the bone. The soft tissues are separated from the bone high enough to expose the saw line. If the muscle cannot easily be retracted, one or two longitudinal incisions through the muscle may be made. The bone is sawed transversely. The femoral, anastomotica magna, branches of the external circumflex, and muscular branches require to be ligated. The muscles should be sewed over the bone end. The skin should be sutured by uniting the lower end to the higher point of incision.

The *racket incision* (Fig. 1966, *B*) is useful also in thigh amputations,

especially in the lower third. Amputation through any part of the thigh may be made by *double flaps*.

Commonly a *long anterior* and a *short posterior flap* are preferred. The anterior flap is usually made 3 times as long as the posterior flap. They are the same size at the base. The anterior flap should have a length equal to 1½ diameters of the thigh at the saw line. Its width should be one-half the circumference of the thigh. It begins on the inner or outer aspect of the thigh opposite the saw line, and passes downward, thence rounds across the front of the thigh, and curves upward, ascending on the opposite side to a point at a level with the saw line. The posterior flap is marked out by an incision which leaves the first incision and curves across the back of the thigh, marking out a flap one-third the length of the anterior flap (Fig.

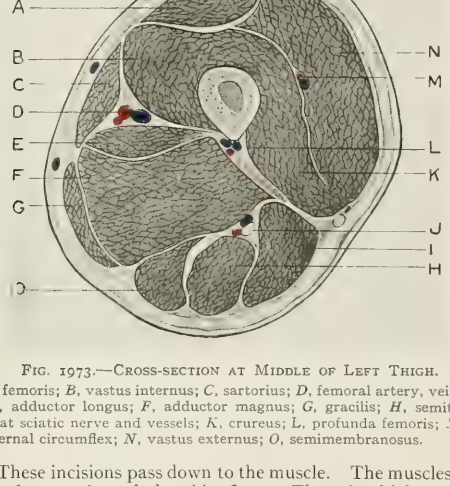


FIG. 1973.—CROSS-SECTION AT MIDDLE OF LEFT THIGH.

A, Rectus femoris; *B*, vastus internus; *C*, sartorius; *D*, femoral artery, vein and saphenous nerve; *E*, adductor longus; *F*, adductor magnus; *G*, gracilis; *H*, semitendinosus; *I*, biceps; *J*, great sciatic nerve and vessels; *K*, crureus; *L*, profunda femoris; *M*, descending branch of external circumflex; *N*, vastus externus; *O*, semimembranosus.

1968, *C*). These incisions pass down to the muscle. The muscles are divided at the line of retraction of the skin flaps. They should be cut obliquely, being bevelled toward the bone. The incision reaches the bone just below the saw line. Here the knife sweeps around the bone dividing everything.

The soft parts are freed from the bone a short distance above the saw line to allow of retraction. The bone is divided. In flaps cut above the middle of the thigh, the femoral, profunda, branches of external circumflex, and muscular branches will be cut in the anterior flap, and the branches of the perforating arteries in the posterior flap. In flaps cut below the middle of the thigh, the femoral, anastomotica magna, and branches of the perforating will be cut in the posterior flap, and branches of the external circumflex, and muscular branches in the anterior flap (Fig. 1973).

The muscles should be sewed together over the end of the bone. Heavy chromic catgut should be used. The skin flaps are then sewed over the muscle.

Amputation with *equal lateral flaps* (Fig. 1974, *A*) is similar to a circular amputation.

Amputation with *equal anterior* and *posterior flaps* is carried out the same as amputation with unequal flaps. Each flap should have a length equal to a little more than three-fourths the diameter of the limb at the saw line. The greater retraction of the posterior flap gives a posterior scar

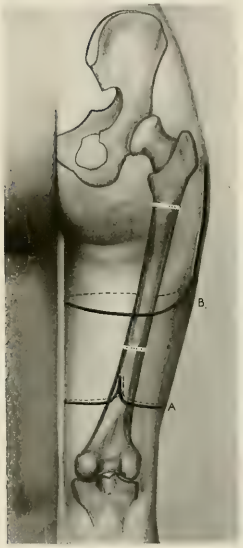


Fig. 1974.

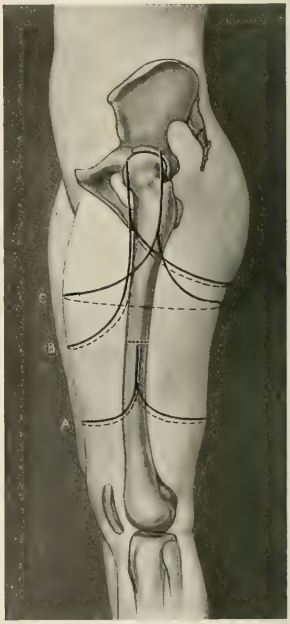


Fig. 1975.

Fig. 1974.—Amputations of Thigh.

A, Amputation of thigh with equal lateral flaps; *B*, subtrochanteric amputation of thigh with external racket incision.

Fig. 1975.—Amputations through Thigh and at Hip-joint.

A, Amputation with equal anterior and posterior flaps; *B*, disarticulation of hip with long anterior and short posterior flaps; *C*, disarticulation with external racket incision.

This is practically a circular amputation with vertical lateral incisions (Fig. 1975, *A*).

In *subtrochanteric amputation*, the *external racket method* is to be recommended. This is practically a circular amputation with an added vertical external incision. The position of the patient is similar to that for disarticulation at the hip-joint. The thigh is adducted. The vertical incision begins above at the outer side of the great trochanter and passes down the outer side of the thigh, dividing as an inverted Y just before it reaches the

level of the circular incision. The circular incision should be a distance below the saw line a little less than three-fourths of the diameter of the limb at the saw line (Fig. 1974, *B*). The vertical incision is deepened to the bone. The muscles are divided at the upper level of the retracted circular incision. The femur, which lies close to the outer side, is divided. The femoral vessels, profunda vessels, internal circumflex artery, branches of external circumflex, comes nervi ischiadici, and muscular branches require to be ligated. The muscles should be sutured over the bone with two layers of chromic catgut sutures, and the skin closed over all.

Disarticulation at Hip-joint.—For the *anatomy* of the hip-joint region, see Fractures (Vol. I, page 583); Dislocations (Vol. I, page 640); Resections

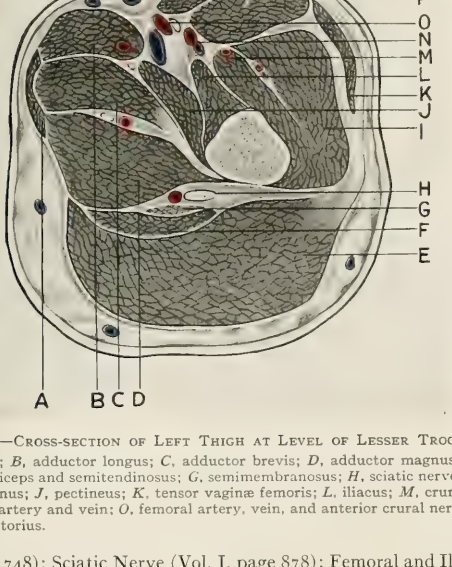


FIG. 1976.—CROSS-SECTION OF LEFT THIGH AT LEVEL OF LESSER TROCHANTER.

A, Gracilis; *B*, adductor longus; *C*, adductor brevis; *D*, adductor magnus; *E*, gluteus maximus; *F*, biceps and semitendinosus; *G*, semimembranosus; *H*, sciatic nerve and artery; *I*, vastus externus; *J*, pectineus; *K*, tensor vaginæ femoris; *L*, iliacus; *M*, crureus; *N*, profunda femoris artery and vein; *O*, femoral artery, vein, and anterior crural nerve; *P*, rectus femoris; *Q*, sartorius.

(Vol. I, page 748); Sciatic Nerve (Vol. I, page 878); Femoral and Iliac Vessels (Vol. I, pages 363 and 429).

The head of the femur fits into the acetabulum of the pelvis where it is held by muscular and atmospheric pressure. The teres ligament and the surrounding ligaments of the joint check extreme movements.

The main arteries passing near the hip-joint are the femoral, obturator, internal pudic, sciatic, iliolumbar, lateral sacral, gluteal, circumflex iliac, superficial epigastric external pudic, profunda, muscular, perforating, and anastomotica magna. Veins accompany the arteries (Fig. 1976)

The nerves of the hip-joint region are from the dorsal and lumbar nerves, from the sacral plexus and coccygeal nerves. The larger nerve trunks are the great sciatic, small sciatic, anterior crural, iliohypogastric, ilio-inguinal, genitocrural, external cutaneous, obturator, accessory obturation, gluteal and pudic.

The head of the femur lies just below and external to the center of Poupart's ligament. The upper border of the great trochanter is on a level with the center of the hip-joint. A line drawn from the anterior-superior spine of the ilium to the most prominent part of the tuberosity of the ischium, passes through the centre of the acetabulum.

The upper border of the great trochanter is 7.5 to 10 cm. (3 to 4 inches) below the crest of the ilium, and 2 cm. (¾ inch) below the top of the head of the femur. The spine of the pubis is slightly above the level of the great trochanter.

When the patient lies supine and relaxed, a triangle is marked out by a line dropped vertically from the anterior-superior spine of the ilium, a second straight line running in the long axis of the thigh and leaving the top of the great trochanter to join the first line at a right angle, and a third line from the anterior-superior spine to the top of the great trochanter. This triangle may be used for comparison with that of the other side.

The posterior-superior iliac spine is just behind the middle of the sacro-iliac joint. The anterior-inferior spine of the ilium is about 2 cm. (¾ inch) above the upper border of the acetabulum.

The tuberosities of the ischia are on either side of the anus. In the erect position they are covered by the lower border of the glutei maximi. When the thigh is flexed they are covered only by fascia and skin. The rounded prominence of the buttock is formed by the gluteus maximus. The fold of the buttock is caused by the folding of the skin in extension of the thigh; it is lower and less oblique than the lower border of the gluteus maximus.

The femoral artery passes to the front and inner side of the hip-joint from which it is separated by the psoas magnus muscle.

The epiphyseal line between the head and neck of the femur is entirely within the capsule of the joint. Ossification in the head begins at the end of the first year. The head unites with the shaft at the eighteenth year. Ossification of the great trochanter begins in the fourth year and of the lesser trochanter in the thirteenth year. They both unite with the shaft about the eighteenth year.

The *general principles* of disarticulation of the hip-joint are different from those in other joints. It is the gravest of the disarticulations. Shock is the great danger. No surgeon should undertake this operation without considering every possible measure for diminishing shock. Nerve blocking by injecting the nerves with anesthetic substances should be done in all cases. This may be done as a preliminary step or the nerves may be injected as they are exposed in the course of the operation (see Shock, Vol. I, page 213; Anesthesia, Vol. I, page 127; Treatment of Nerves in Amputations, Vol. I, page 146; Prevention and Arrest of Hemorrhage, Vol. I, page 334).

The *control of hemorrhage* is most important. Several methods are available.

The control of hemorrhage by *long pins and elastic tourniquet* (Wyeth) is as follows: Two steel pins are used. They should be about 28 cm. (11 inches) long and 6 mm. (¼ inch) thick, having a head at one end and a point at the other. The point should be covered with cork after the pin is inserted. The external pin is inserted just below and to the inner side of the anterior-superior spine of the ilium, passes outward and backward through the skin, fascia and superficial muscles, and emerges about 7.5 cm. (3 inches) external to the point of entrance. The internal pin is inserted on the inner aspect of the thigh just internal to the saphenous opening, 1.3 cm. (½ inch) below the crotch, passes backward and downward through the adductor muscles and emerges 2.5 cm. (1 inch) below the tuberosity of the ischium. The limb is elevated and emptied of blood by stroking or by the use of the rubber bandage of Esmarch. Then strong rubber tubing, 1.3 cm. (½ inch) in diameter, is wound 4 or 5 times tightly around the hip above the pins and clamped. The pins serve the purpose of preventing slipping and displacement of the tubing. The tubing compresses the femoral artery against the pubic bone, as it crosses the pelvic rim, and the gluteal, sciatic, and internal pudic vessels against the ischium, as they emerge from the great sacrosciatic foramen (Fig. 1977).

The *control of the tourniquet by means of a bandage* is quite satisfactory, but not so secure as by the pins. After elevating the limb and allowing the

blood to leave its vessels, a strong strip of muslin bandage should be laid along the front and another along the back of the trunk and thigh. Rubber tubing, as above, is then passed tightly around the hip in such a way that it lies between the anus and tuberosity of the ischium, crosses the brim of the pelvis, and lies internal to the anterior-superior spine of the ilium. The pieces of bandage are then picked up in such a way that each forms a loop embracing the rubber tubing. One loop is carried across the back and the other across the front of the pelvis. These two loops may be held in the hand of an assistant or they may be tied together on the opposite side of the pelvis. If the latter expedient is resorted to, each loop should first be tied down upon the tourniquet with a square knot, then they should be tied together or clamped on the opposite side of the pelvis where the bandage is kept from slipping by being fixed to the skin with two strips of adhesive plaster, forming an eye. If the tubing is applied tight enough no compressing pad over the femoral vessels is necessary.

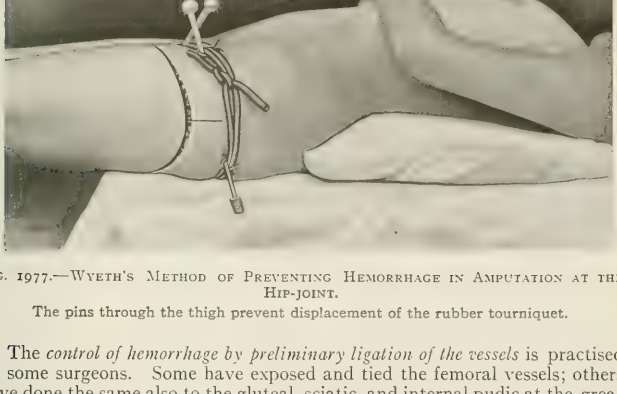


FIG. 1977.—WYETH'S METHOD OF PREVENTING HEMORRHAGE IN AMPUTATION AT THE HIP-JOINT.

The pins through the thigh prevent displacement of the rubber tourniquet.

The *control of hemorrhage by preliminary ligation of the vessels* is practised by some surgeons. Some have exposed and tied the femoral vessels; others have done the same also to the gluteal, sciatic, and internal pudic at the great sacrosciatic foramen. There is no advantage in making a special operation of this as it can be done through the incision of amputation as the vessels are exposed.

By *tourniquet transfixion of the thigh* is meant the method devised by Senn. A longitudinal incision is begun 7.5 cm. (3 inches) above the great trochanter and carried downward 20 or 23 cm. (8 or 9 inches). The joint is exposed and the head of the femur disarticulated (see Resection of Hip, Vol. I, page 748). A pair of long forceps is passed into the wound behind the femur at the level of the lesser trochanter, and guided behind the adductor muscles until the point reaches the skin on the inner side of the thigh just below the crotch. Here the skin is incised, the forceps caused to emerge, and grasp two pieces of rubber tourniquet tubing. These are drawn through the wound. One is passed in front and the other behind the femur. The limb is then elevated to allow the blood to flow out of it into the other vessels, and the

two tourniquets are thrown round the limb, and clamped, one in front and the other behind. This method has little to recommend it. It distorts the flaps, and difficulty may be experienced in preventing downward displacement of the tourniquets.

The use of *acupression* was advocated by Trendelenburg. A pin or pointed rod was thrust through the tissues between the femoral vessels and the bone. Rubber tubing was wound about this in figure-of-eight form, thus compressing the vessels. This has no advantage over ligation of the vessels, but may sometimes be of use in emergencies. This same result is secured with a long clamp, one blade of which is thrust through the tissues, between the bone and the vessels, the other blade closes down on the skin.

The cinematic principle may be employed at the hip, preserving muscles to perform all of the hip-joint motions. The muscular stumps which are covered with skin should have their ends well reinforced by fascia or tendon to make the loop hole secure.

Disarticulation at hip-joint by anterior racket incision may best be carried out with hemostasis by means of pins and tourniquet or the bandage and tourniquet method. It can be done without any tourniquet, the vessels being tied as they are encountered. The patient should lie with the pelvis at the foot of the table. An incision is begun at the center of Poupart's ligament, and passes downward along the course of the femoral artery for about 7.5 cm. (3 inches). It then curves inward and transversely crosses the inner side of the thigh about 10 cm. (4 inches) below the genitocrural fold of the crotch, and around the back and outer side of the thigh to the front. As it reaches the front of the femur, it curves upward and inward and joins the first incision about 5 cm. (2 inches) below Poupart's ligament (Fig. 1972, *B*).

The first line of incision passes through skin and fascia. The incision is then retracted at its upper end, the anterior crural nerve lying external to the artery, is injected with anesthetic, and the femoral artery and vein are each tied in two places and cut between the ligatures. The incision is then deepened in line with the upper border of the retracted skin. The anterior and external muscles are divided—sartorius, rectus, tensor vaginæ femoris, vastus externus and crureus. The external circumflex artery, lying behind the sartorius and rectus and in front of the crureus, should be tied and the thigh is then rotated inward, the gluteus maximus divided, and the sciatic nerve exposed. The nerve is injected with anesthetic, and the artery and vein are tied and divided. The anterior crural nerve is then divided. The thigh is then rotated outward and the internal muscles divided—adductors, pectineus and a gracilis. The obturator and the profunda femoris vessels are tied and cut. Then the posterior muscles are divided—this is the hamstring group. Division of the sciatic nerve follows. As the divided muscles retract, the muscles attached to the trochanters are divided. All of the structures are then cut down to the joint capsule. The capsule is opened transversely in front, the round ligament cut, the head disarticulated, and the rest of the joint capsule divided. This completes the disarticulation. Internal circumflex, muscular, and perforating arteries are ligated. The muscles are quilted by several layers of strong chromic catgut sutures across the joint. A drain is passed down to the acetabulum. The skin is sutured in a continuous anteroposterior line.

Disarticulation at hip-joint by external racket incision is best carried out with tourniquet hemostasis, the tourniquet being held by pins or bandages. A circular incision is made horizontally around the thigh 10 cm. (4 inches) below the genitocrural fold of the crotch. The external incision begins

midway between the tourniquet and the top of the great trochanter, and passes downward on the outer aspect of the hip to join the circular incision as an inverted Y rather than at right angles (Fig. 1975, *C*). The circular incision for this reason may be left interrupted at its outer part. It should pass down to the muscle, and be retracted upward for about 5 cm. (2 inches). At this level the muscles are divided circularly to the bone. The vessels and nerves are treated as in the above operation. The vertical incision is carried down to the bone throughout its whole extent. The muscles are then dissected from the bone up to the pelvis and retracted. The joint capsule is incised anteriorly and the incision enlarged until the head can be lifted up and the round ligament cut. The remainder of the capsule is then divided, and the disarticulation completed (Fig. 1978). The muscles should be treated the same as in the preceding operation. The skin is sutured in a continuous vertical and transverse line.

There is little choice between the two above-described methods of disarticulation. The external racket incision may be modified so that it becomes a *disarticulation with long anterior and short posterior flaps* (Fig. 1975, *B*).

FIG. 1978.—AMPUTATION AT HIP-JOINT BY EXTERNAL RACKET INCISION AND PINS TO HOLD TOURNIQUET CONSTRICTOR.

In such operations as these, if the disease will permit, the rectus, the adductors, or the glutei muscles may be preserved and wrapped in a flap of skin, to be used later to supply motion to an artificial leg (see Cineplastic Amputations, page 526).

Interilio-abdominal Amputation (Transpelvic Amputation).—This operation is done in cases in which an operation higher than disarticulation of the hip is necessary. Usually it is done for neoplasm involving the hip-joint. Part or all of the ilium may be removed; or in addition to this, pubic bone or ischium may be sacrificed. The operation should be done preferably without opening the peritoneum. If the dissection indicated is not too wide, the same measures for hemostasis as are employed in hip disarticulation may be used. Usually these cannot be employed. Compression of the aorta by hand or the tourniquet may be used (see Abdominal Tourniquet, Vol. I, page 363). It is often best to dispense with these measures entirely and tie vessels as they appear in the wound. The blood should be expelled from the leg by elevation and the elastic bandage. This is the most serious

of all amputations and every means for preventing shock and saving blood should be employed.

The incision must vary with the location of the disease and amount of pelvis to be removed. In the typical case a long internal flap is to be preferred. An incision is begun just above the middle of the crest of the ilium. It passes forward to the anterior-superior spine, and thence curves downward and inward to a point just above and external to the middle of Poupart's ligament. Through this incision the internal iliac artery is ligated external to the peritoneum (see Extraperitoneal Ligation of Internal Iliac Artery, Vol. I, page 430).

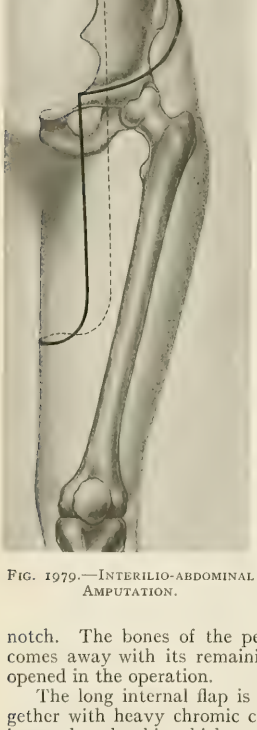


Fig. 1979.—Interilio-abdominal Amputation.

From the inner end of the first incision a vertical incision is carried downward across Poupart's ligament and external to the course of the femoral artery. This incision should be so planned that the femoral artery is preserved in the long internal flap. This flap is made by carrying the vertical incision downward to the middle of the front of the thigh. It curves inward around to the back of the thigh, and thence vertically upward to the crest of the ilium in front of the posterior-superior spine. The incision above the crest of the ilium is then continued to connect with this point (Fig. 1979). This passes through skin and fascia. This incision is then deepened through the muscle. As the muscles of the thigh are divided through the transverse incision the femoral vessels are exposed, tied and divided.

The muscles attached to the crest of the ilium from above are divided down to the peritoneum. The psoas and iliacus are separated from the inner surface of the ilium. The pelvic bones are divided at the desired points. It is better to divide the horizontal and descending rami of the pubic bone than to disarticulate at the symphysis pubis. By so doing the rectus abdominis muscle and the corpus cavernosum are preserved. This should be governed, however, by the extent of the disease. The ilium is divided posteriorly by sawing externally to the sacroiliac joint. The saw line runs into the sacrosciatic notch. The bones of the pelvis having been divided the lower extremity comes away with its remaining pelvic attachments. The hip-joint is not opened in the operation.

The long internal flap is turned upward. The muscles are quilted together with heavy chromic catgut. The skin of the lower end of the flap is sewed to the skin which was incised above the crest of the ilium.

In order to secure firm support to the weakened abdomen, the muscles should be well sewed, and the flap should be held in place by firm and even pressure.

The incision for this amputation used by W. W. Keen extends from the spine of the pubes 2 cm. ($\frac{3}{4}$ inch) above and parallel with Poupart's liga-

ment and the crest of the ilium, to about the middle of the crest. After ligating the internal iliac artery, the incision is continued nearly to the posterior-superior iliac spine.

The thigh incision begins just external to the middle of Poupart's ligament and passes downward and then inward to the middle of the thigh at its inner surface, thence curving to the middle of the back of the thigh, upward and outward to the back of the femur, to the posterior-superior spine of the ilium.

The internal iliac artery is exposed extraperitoneally. The thigh incision is made external to the center of Poupart's ligament in order to preserve the femoral vessels. The femoral vessels are tied at the transverse division of the soft tissues in the middle of the thigh.

W. W. Babcock (Surg., Gyn. and Obst., May, 1918) employed an incision which retains none of the tissues of the thigh and which removes the inguinal lymphatics and part of the lower abdominal wall. The first incision begins about 4 cm. above the spine of the pubis, curves upward to a point about 8 cm. above the middle of Poupart's ligament, and ends about 4 cm. above the anterior-superior spine of the ilium. This incision should pass well above any infiltrated area. Through this the epigastric, superficial circumflex, and external iliac vessels are tied. The internal iliac is temporarily occluded by a clamp. From the outer end of the first incision a second incision passes downward and backward to the great trochanter. The iliopsoas muscle is divided fairly high. Poupart's ligament is cut, and the acetabulum exposed. The incision is continued, the joint disarticulated, and the great sciatic nerve exposed, injected with 2 per cent. novocain, and divided. From the great trochanter the incision is continued parallel with the gluteal fold and thence adjacent to the perineum, and so on to the beginning of the first incision. As much pelvic bone as necessary may be removed.

This operation of Babcock possesses the advantage that the vessels are ligated as an early step and none of the trurniquet devices are necessary. It gives free exposure of the gtoin lymphatics. The peritoneum should not be opened but simply stripped back. The posterior flap covers the wound.

ARTIFICIAL LIMBS AND PROSTHETIC APPARATUS

Apparatus for the Upper Extremities

Motor Apparatus.—For cineplastic stumps, apparatus with movable joints is made. Apparatus to flex the elbow is simple. Movable fingers are the important desiderata. A cord is conducted from the motor stump to cause flexion of the fingers. Extension is accomplished by springs, although the extensor muscles may be employed for this purpose. The principle consists in conducting a cord from the muscles to the artificial parts to be moved. There need be no limit to the refinement of this apparatus, even to the degree of preserving the function of every important muscle. All that is required is that a means for attaching the cord to the muscle or muscles shall be provided (see Cineplastic Amputations, page 526). This is best done by the plastic construction of a small hole made by looping the end of the tendon or by sewing two or more tendons together.

Suggestions for the mechanics of the hand are shown in Figs. 1980, 1981, 1982 and 1983.

For flexing the artificial elbow a cord conducted from a motor stump may be used, or the method of Carnes may be employed. The same also with the shoulder-joint.

Movable joints without cineplastic stumps have been produced by Mr. Carnes of Kansas City, Mo. Movements of the artificial joints are produced by utilizing the movements of the upper arm stump and the shoulder. By these means it is possible, in a stump resulting from amputation above the

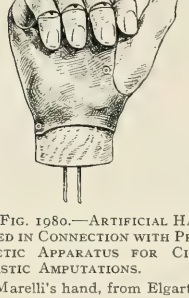


FIG. 1980.—ARTIFICIAL HAND USED IN CONNECTION WITH PROSTHETIC APPARATUS FOR CINEPLASTIC AMPUTATIONS.
Marelli's hand, from Elgart. (*Keen.*)

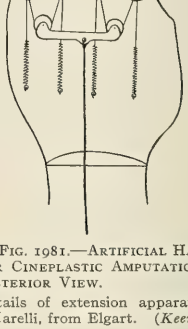


FIG. 1981.—ARTIFICIAL HAND FOR CINEPLASTIC AMPUTATIONS. POSTERIOR VIEW.
Details of extension apparatus. Marelli, from Elgart. (*Keen.*)

elbow, to provide flexion and extension of fingers, rotation of forearm, and flexion and extension of the elbow. These movements are accomplished largely by shrugs of the shoulder (Figs. 1984 and 1985).

The elbow is flexed by flexing the shoulder joint. The simple act of moving the arm forward puts tension on a posterior cord which passes through the apparatus and acts on the forearm. The hand rotates as the elbow is flexed. The elbow is provided with mechanism by which it may be locked at a right angle or in any other position.

The wrist is flexed and extended by raising and lowering the shoulder. By pressing a

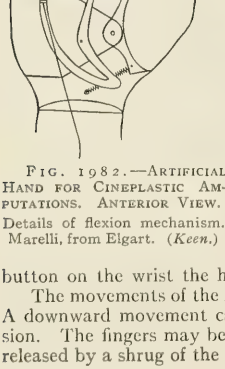


FIG. 1982.—ARTIFICIAL HAND FOR CINEPLASTIC AMPUTATIONS. ANTERIOR VIEW.
Details of flexion mechanism. Marelli, from Elgart. (*Keen.*)

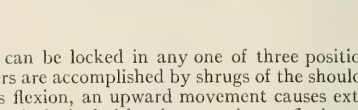


FIG. 1983.—FINGER OF ARTIFICIAL HAND FOR CINEPLASTIC AMPUTATION.
Marelli, from Elgart. (*Keen.*)

button on the wrist the hand can be locked in any one of three positions.

The movements of the fingers are accomplished by shrugs of the shoulder. A downward movement causes flexion, an upward movement causes extension. The fingers may be securely locked either in extension or flexion and released by a shrug of the shoulder.

W. S. Bickham adapted the above apparatus to the cineplastic stump (Figs. 1986 and 1987). The superficial appearance of the artificial arm is shown in Figs. 1988, 1989 and 1990. The fingers are best made of bamboo wood. The arms are made of wood, papier machè, aluminum, or combinations of these.

Simple Apparatus.—Artificial arms are made also for purely cosmetic purposes. Modern methods have rendered such apparatus quite obsolete.

The old-fashioned "hook-arm," which provided a prehensile hook, performs good service in the absence of something better. In the place of the hook other removable utensils may be employed. A socket is made to receive a knife, fork, tooth-brush, hook, or artificial hand.

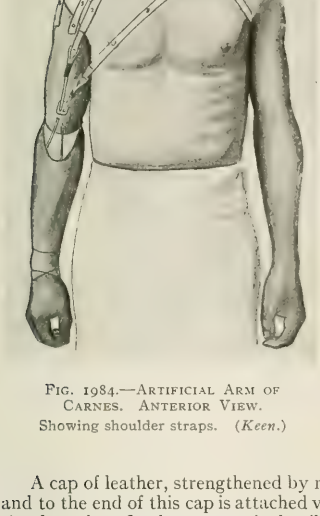


FIG. 1984.—ARTIFICIAL ARM OF CARNES. ANTERIOR VIEW.
Showing shoulder straps. (*Keen.*)

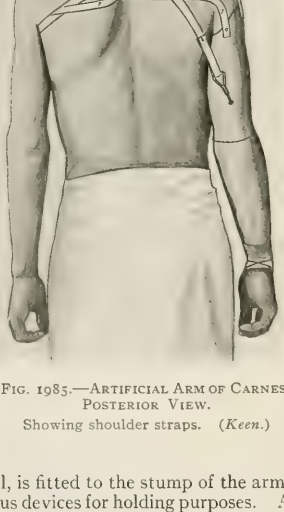
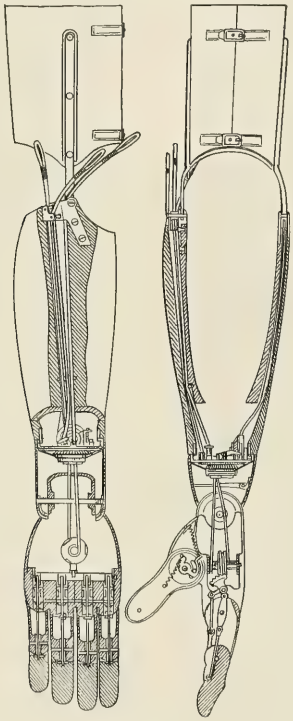


FIG. 1985.—ARTIFICIAL ARM OF CARNES. POSTERIOR VIEW.
Showing shoulder straps. (*Keen.*)

A cap of leather, strengthened by metal, is fitted to the stump of the arm, and to the end of this cap is attached various devices for holding purposes. A simple socket, fixed upon a swivel, will receive the end of a shovel, the handle of a wheelbarrow, the handle of a scythe, or other implement. Such apparatus may be constructed for the upper arm (Fig. 1990*a*) or for the forearm (Fig. 1990*b*).

Apparatus of this kind may be provided with an adjustable hook or clamp (Fig. 1990*c*) which the worker may manipulate with the help of the sound hand or with some other part. A man fitted with this simple apparatus may quickly learn to perform work with efficiency quite equal to that of a two handed person. Such functions as shoveling dirt or spading (Fig. 1990*d*) may be carried out with remarkable facility. The handling of such a mechanism as a wheelbarrow may be performed nearly as well as with two hands (Fig. 1990*e*).

The patient who has lost both hands may be fitted with a simple apparatus and perform many of the ordinary services of labor (Fig. 1990*f*). The claw or clamp equipment, shown in Fig. 1990*c*, is especially adapted to the uses of the mechanic, who with such an apparatus may hold a chisel (Fig. 1990*g*) or other instrument and find himself not seriously handicapped in the pursuit of his calling. A clamp may be used to hold a hammer to the injured



FIGS. 1986 AND 1987.—BICKHAM'S ADAPTATION OF THE CARNES ARM TO THE CINEPLASTIC STUMP. (*Keen.*)

arm when the convenience of the worker will be best served by such an arrangement (Fig. 1990*h*).

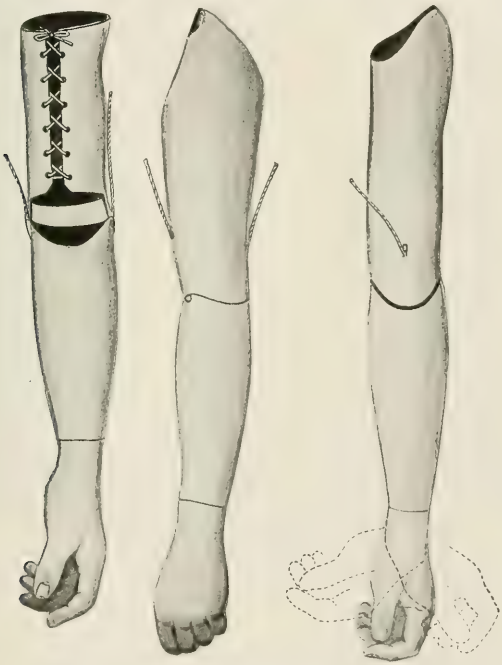
For more complicated work special holding devices may be employed. There is, perhaps, no hand-grasping function which cannot be imitated by prosthetic apparatus. With a stem and pin for fitting into a handle socket and a clamp to hold a whetstone, the farmer may not only manipulate (or mechanipulate) his scythe but he may sharpen it as well (Fig. 1990*i*). A special socket may be fitted to the end of the stump-cap which may serve for

holding and making pressure in the lathe-worker's pursuit of his trade (Fig. 1990*j*).

The man who has lost an arm by disarticulation at the shoulder may have such an apparatus adjusted to a shoulder cap. For special work the attachment may be made at the waist (Fig. 1990*k*).

Apparatus for Lower Extremities

Motor Apparatus.—For cineplastic stumps in the lower extremities apparatus with movable joints may be made. Such apparatus, of course,



Figs. 1988, 1989, 1990.—Superficial Appearance of Artificial Arm. (*Keen.*)

is of much less utility than in the arm. The artificial joints which it is desirable to bring under voluntary muscular control are the ankle, knee, and hip. For control of the ankle, the anterior and posterior, one or both, muscles of the leg may be used. For the knee, the thigh muscles may be employed. Motion at the hip may be secured by preserving the anterior muscles secured by preserving the anterior muscles for flexion, and the glutei

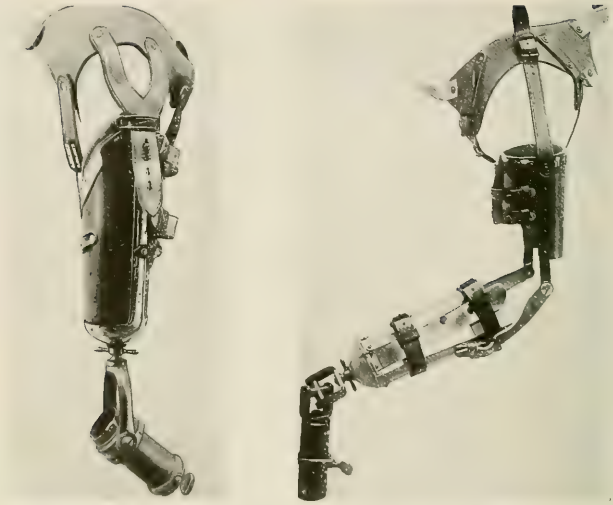


FIG. 1990a. FIG. 1990b.

FIG. 1990a.—APPARATUS FOR STUMP OF UPPER ARM.
Showing cup fixed on swivel for reception of implement.

FIG. 1990b.—APPARATUS FOR STUMP OF FOREARM.
Showing universal swivel holding cup for receipt of implement. This apparatus is made fast at the shoulder and embraces the upper arm as well as the forearm.

FIG. 1990c.—APPARATUS FOR STUMP OF UPPER ARM, WITH CLAMP DEVICE.

and the muscles arising from the ischium for extension. There is no reason why adductors and abductors also should not be preserved. The same principles as are used in the arm apply to the leg.

Movable joints without cineplastic stumps are commonly employed. For the ankle a slightly movable joint is made to avoid stiffness. Springs for extension and springs for flexion are so adjusted that they balance one another, but give elasticity to the ankle. The knee is so constructed that it simply swings through the larger part of the natural arc and holds itself in

FIG. 1990*d*. FIG. 1990*e*.

FIG. 1990*d*.—APPARATUS FOR STUMP OF FOREARM.
Showing cap applied to handle of shovel.

FIG. 1990*e*.—APPARATUS FOR STUMP OF FOREARM TO TAKE THE PLACE OF THE ABSENT HAND.
The swivelled cup fits the handle of a wheelbarrow.

the position of full extension. Hip-joint apparatus has usually been made fixed to the pelvis, with little or no attempt at an artificial joint.

Simple Artificial Feet and Legs.—The stump should fit in its socket so easily that pressure is not made. The stump is much more comfortable if it can be lifted free from its casing occasionally while the whole weight is borne on the other leg. The feet are constructed of spongy rubber or other springy substance. The ankle is provided with rubber-elastic or metal springs (Fig. 1991). Many people, after much experience prefer a rigid ankle with a spongy rubber-foot. For partial amputations of the foot or disar-

ticulation at the ankle a boot which laces over the leg carries the artificial foot (Figs. 1992 and 1993).

For amputations above the ankle and below the knee the apparatus must have a cuff which embraces the thigh. An artificial leg and foot having a hinge at the knee, is employed (Fig. 1994). The most comfort is secured by having the whole apparatus suspended by straps over the shoulders (Fig. 1995); or the straps may be attached to a corset or belt. For amputations at the knee and in the thigh a similar mechanism is used. A device for locking the knee so that it can not bend may be attached. In order to secure ease of motion a spring and piston mechanism is also used at the knee (Fig. 1996).

FIG. 1990.—APPARATUS FOR DOUBLE AMPUTATION OF FOREARMS.
Showing end mechanism adapted to hold a shovel.

Hip-joint amputations require a special pelvic girdle and a joint at the hip; otherwise the apparatus is the same as for the leg and thigh (Fig. 1997).

Peg-legs consist of a wooden post, surmounted by a socket of hollowed-out wood to receive the stump (Fig. 1998). They may be made short or long enough to give the cripple his natural height.

End-bearing stumps are always to be secured if possible. Otherwise the weight must be supported by lateral pressure or by pressure upon the bony prominences above the stump. This must modify the character of the socket into which the stump is received.

Reeducation of the Crippled

The treatment of the man who has suffered an amputation does not end with the completion of the operation, the healing of the wound, nor the fitting with a prosthetic apparatus. The serious business only then begins; and this consists in restoring the cripple to usefulness and a consciousness that there is an important rôle in life for him to play.

This task must be given thoughtful consideration. As a rule it should be assumed that the injured person should remain in the occupation in which he was formerly employed, and prosthetic apparatus and his reëducation should aim at that object. Still an absolute handicap may prevent this. A

Fig. 1990g.—Clamp Apparatus in Action.
The clamp grasps a chisel while the sound hand holds the hammer.

professional typist, who has lost both arms, must be prepared for other employment; the handicap for his former occupation would be too great. In general the man who has lost a leg should be prepared for an occupation in which the legs do not play an important part. The choice of occupations for cripples and their training for useful service has now received scientific attention and has become a matter for expert consideration.

Already, schools for the reëducation of cripples have been established in many countries. Careful consideration is given to training men to overcome

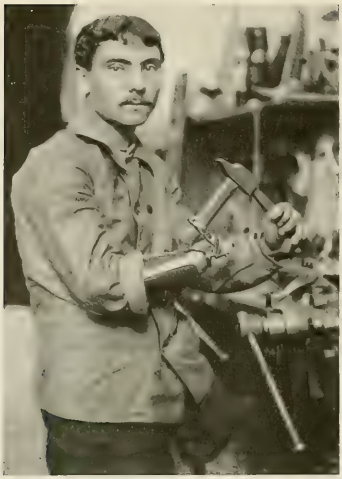


FIG. 1990*h*.—CLAMP APPARATUS FOR HOLDING HAMMER.

FIG. 1990*i*.—APPARATUS APPLIED TO AMPUTATION OF FOREARMS.
A pin is used on one arm and a clamp on the other.

FIG. 1990*j*.—APPARATUS APPLIED TO STUMP OF FOREARM.
The end cap is provided with a cup for holding and making pressure.

FIG. 1990*k*.—APPARATUS FOR HOLDING IMPLEMENT IN CASE OF AMPUTATION AT SHOULDER.

FIG. 1991.—ARTIFICIAL FOOT WITH SOLE MADE OF SPONGY RUBBER.

FIG. 1992. FIG. 1993.

FIGS. 1992 AND 1993.—APPARATUS FOR PARTIAL AMPUTATION OF THE FOOT.

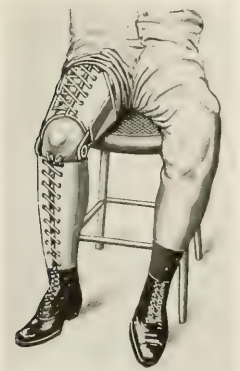


FIG. 1994.—ARTIFICIAL LEG USED IN AMPUTATIONS BELOW THE KNEE.

FIG. 1995.—ARTIFICIAL LEG.
Showing lacing for grasping high.

their physical handicaps. So much progress has this work made that the newer education is demanding that there shall be no more cripples. This means that the maimed person shall not sit around in idleness as an object of charity and pity for the rest of his life, but that he shall take his place by the side of his fellow men in useful service. The trade schools for cripples are accomplishing remarkable work. The national labor exchanges are following it up. In some countries the state is paying to the handicapped man the discrepancy between his productive value and the minimum wage in his trade. Occupation is the best curative agent that can follow the work of the surgeon. Idleness and uselessness are poor results for surgery to have accomplished.

FIG. 1996.—ARTIFICIAL LEG FOR THIGH AMPUTATION.

FIG. 1997.—ARTIFICIAL LEG FOR HIP AMPUTATIONS.

The finer and more intricate apparatus, such as is employed in connection with cineplastic stumps, the average worker in heavy employment does not care to use. He is apt to become impatient and abandon it for the simple and stronger appliances. Workers prefer the peg-leg for rough every-day use; although the apparatus which most resembles the natural limb is preferred for leisure-time dress occasions.

It has been found in the schools for reëducation at Chailey, Port-Villez, Turin, and Düsseldorf that the best teachers are the cripples themselves. Nothing gives a handicapped man so much encouragement as contact with men who have overcome their handicaps. The worst treatment which the cripple can suffer is to be treated as a helpless object of pity, and made the pampered prey of sentimental philanthropy. The old practice of assuming

that war cipples and industrial cripples were helpless has done more to make them so than has their physical disability. Idleness has been their greatest calamity.

After amputations of the arms it is possible to educate the legs and feet to perform functions formerly performed by the amputated members. Thus the typist who has lost one hand may attach to his machine a connection for operating the shift key with the foot. The possibilities of training muscles to perform new feats are infinite.

During the war this question of rehabilitation of the crippled received so much attention that it developed not only special institutions but a

FIG. 1998.—PEG LEGS.

The most simple, and not to be despised, prosthetic apparatus for the lower extremities.

literature as well. The reader is referred to such periodical publications as Recalled to Life (London); Bulletin on Reconstruction and Reëducation of the Disabled Soldier, published by the Surgeon General's Office, U. S. A.; the American Journal of Care for Cripples (New York); and the publications of the Red Cross Institute for Crippled and Disabled Men (New York). This latter organization furnishes specific information on the methods of reëducational work and gives instruction in the technic of training and in the employment of industrial cripples. The pictures of industrial prosthetic apparatus shown in the series 1990*a* to 1990*k* are from its collection.

PLASTIC AND COSMETIC SURGERY

PRINCIPLES OF PLASTIC SURGERY

The mobility and elasticity of the skin are made use of in filling uncovered gaps and in changing the contour of the outer parts of the body. Advantage is taken of these properties for the purpose of promoting healing and for the purpose of improving the appearance of the parts. Such operations are conducted under the same surgical principles as are applied in other operations. Aseptic healing is the most important prerequisite for success; the second prerequisite is nice apposition of the wound edges; and the third requirement is adequate nourishment of the parts, secured by preserving the blood-vessels and avoiding tension. Success is obtained only by attention to details. There are other branches of surgery which require more knowledge of anatomy and pathology, but no department of surgery requires so much surgical skill. The surgeon who succeeds best at this branch of surgery must have a special genius for taking pains in his work. Slap-dash methods, trusting too much to the resistance of the tissues, leaving dressings to unskilled hands, and operating under makeshift conditions, not absolutely controlled by the surgeon, all spell failure. While failure in plastic surgery does not often hazard life it often jeopardizes forever the success of subsequent operations.

In operations about the face the anesthetic should be given in such a way as not to disturb the asepsis. Special pains are called for in the preliminary cleansing of the skin. Iodin is most valuable in this field (see Preparation for Surgical Operations, Vol. I, page 177).

A thin, narrow, very sharp knife is necessary for making curved incisions. In cosmetic operations about the face incisions should be made obliquely rather than at right angles to the surface. Sutures should be not more than 6 mm. (¼ inch) apart when passed through the skin. On the face the subcuticular suture, or the continuous suture of fine silk is to be preferred. Very fine silk is best for through-and-through sutures. For the subcuticular suture paraffined-silk or fine silver wire is best. This latter may be supplemented with a few transcuticular sutures. Fine flat needles should be used in preference to needles which make a three-cornered puncture. Small needles should be held in a needle-holder.

It should be remembered that a flap after it is freed loses about one-third of its size from elastic contraction. In suturing skin wounds for cosmetic purposes, if there is tension on the suture line, the scar will become broad and unsightly. By applying superheated air to the skin about a wound it becomes loosened and tension is much reduced. This may be done after a wound has been sutured; and the danger of a widening scar may thus be reduced.

Incisions about the head may be made through the shaved hair-bearing skin, and scars thus hidden. Operations on the neck may be done through incisions made in the hairy scalp. Operations on the forehead may be done through incisions in the eyebrow or hairy scalp. When the hair grows the scars are hidden.

Flaps should be traumatized as little as possible (Fig. 1999). The skin

should not be grasped with forceps. When forceps must be applied it should be only to the subcutaneous tissue (Fig. 2000). Flaps are best drawn in place by a suture (Fig. 2001).

For cosmetic purposes curved incisions are best because they are less conspicuous than straight incisions. Incisions should follow the natural creases of the skin.

In cutting flaps, the base of the flap should be placed if possible toward the direction from which the blood supply flows. If possible a good-sized ves-

FIG. 1999.—HOW NOT TO GRASP SMALL SKIN FLAPS.

This method contuses the apex of the flap and favors sloughing.

FIG. 2000.—PROPER MANNER OF GRASPING THE APEX OF A SMALL SKIN FLAP.

The forceps grasp only the subcutaneous connective tissue but do not touch the skin.

sel should be included in the pedicle. It is best that the vessels of the flap should be empty before it is transplanted, as circulation is established better than when the vessels are filled with clots. It has long been observed that pale flaps do better than red flaps.

A flap should not be implanted upon cicatricial tissue or in an area surrounded by dense scar, because the blood-vessels are so compressed by scar that the flap will not receive adequate nourishment. In such situations the

FIG. 2001.—MANNER OF DRAWING FLAP OF SKIN IN PLACE BY MEANS OF THE APICAL SUTURE.

scar should first be cut away. Flaps are prone to become edematous. This subsides slowly as circulation is established.

After a flap has been sewed in place, if it is slow in establishing circulation and is cold and begins to look cyanotic, its vitality may be restored by heat. A salt solution dressing should be applied and this kept warm by covering it with a hot-water bag having a temperature of about 47°C. (116°F.). Or a rubber coil, with heated water running through it, may be incorporated

in the dressing. If the location permits, the vacuum suction apparatus may be used to encourage the blood to enter the part.

Necrosis usually appears during the first three or four days if it is going to appear at all. A flap which is overcongested, swollen, edematous, and suffering with stasis, may be saved by incising it to allow some of the blood and serum to escape. A flap which is infected and dead and unmistakedly fallen into necrosis should be cut away. A darkened, dry, and mummified

FIG. 2002.

FIG. 2003.

FIG 2002.—ELLIPTICAL WOUND WHICH MAY BE CLOSED BY STRETCHING THE SKIN.
FIG. 2003.—CLOSURE OF ELLIPTICAL WOUND BY STRETCHING THE SKIN.

area may mean only superficial necrosis; such an area need not be cut away at once but may be given time to separate spontaneously.

The use of *silver foil as a wound covering* is especially advantageous in plastic surgery. A wound which has been nicely sutured may have placed directly upon the skin a layer of sterilized silver foil. Over this to keep it smooth may be placed a layer of soft paper or fine cotton cloth; then a few layers of gauze to give gentle compression. If the wound has been closed

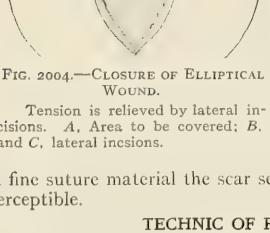


FIG. 2004.—CLOSURE OF ELLIPTICAL WOUND.

Tension is relieved by lateral incisions. *A*, Area to be covered; *B*. and *C*, lateral incsions.

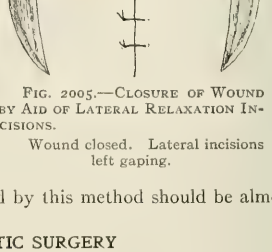


FIG. 2005.—CLOSURE OF WOUND BY AID OF LATERAL RELAXATION INCISIONS.

Wound closed. Lateral incisions left gaping.

with fine suture material the scar secured by this method should be almost imperceptible.

TECHNIC OF PLASTIC SURGERY

Plastic surgery employs the following principles: (1) Stretching the skin at the edge of a wound; (2) undercutting the skin at the edge of a wound to permit further lateral displacement; (3) lifting up an area of skin as a

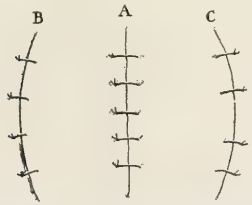


FIG. 2006.—CLOSURE OF WOUND BY AID OF LATERAL RELAXATION INCISIONS. *A*, Wound closed; *B* and *C*, lateral incisions closed.

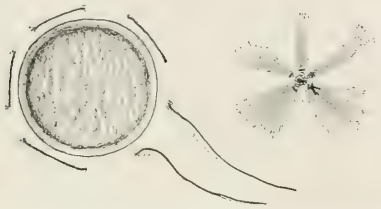


FIG. 2007.—CIRCULAR WOUND CLOSED BY PURSE-STRING SUTURE.

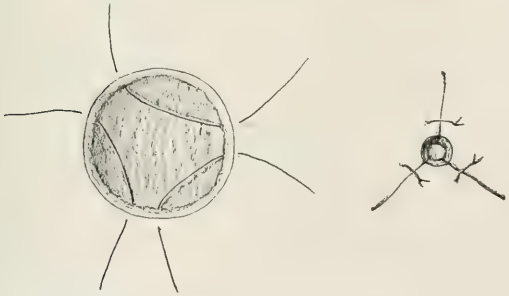


FIG. 2008.—CIRCULAR AREA CLOSED IN THE FORM OF A Y.

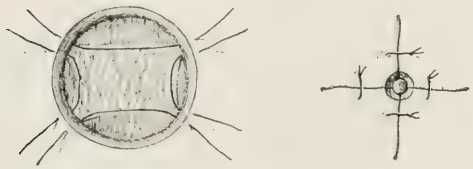


FIG. 2009.—CIRCULAR WOUND CLOSED BY CRUCIAL SUTURING. Accessory sutures must be added to those here shown.

valve or sliding flap; (4) lifting up a flap of skin which is left attached only by a pedicle and turning it into a new position; (5) twisting a pedunculated flap so that the skin surface faces toward the body; (6) cutting under a segment of skin, marked out by two parallel incisions, to create a bridge which may be connected with another flap; (7) uniting two flaps in such a

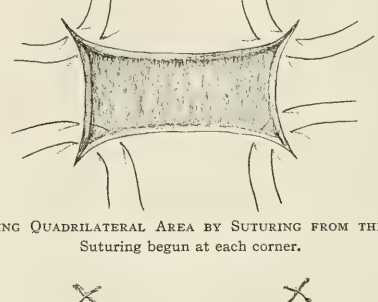


FIG. 2010.—CLOSING QUADRILATERAL AREA BY SUTURING FROM THE FOUR CORNERS. Suturing begun at each corner.

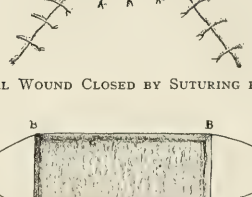


FIG. 2011.—QUADRILATERAL WOUND CLOSED BY SUTURING FROM THE FOUR CORNERS.

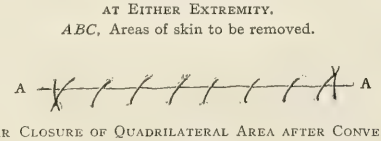


FIG. 2012.—QUADRILATERAL WOUND CONVERTED INTO ELLIPSE BY REMOVING TISSUE AT EITHER EXTREMITY.
ABC, Areas of skin to be removed.

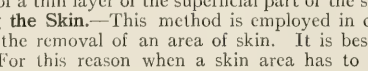


FIG. 2013.—LINEAR CLOSURE OF QUADRILATERAL AREA AFTER CONVERTING IT INTO AN ELLIPSE.

manner as to produce a flap having epithelium on both sides; (8) transplantation of a detached segment of the whole thickness of the skin; and (9) transplantation of a thin layer of the superficial part of the skin.

1. **Stretching the Skin.**—This method is employed in ordinary wounds remaining after the removal of an area of skin. It is best adapted to elliptical areas. For this reason when a skin area has to be removed, its

closure is best accomplished if the area is in the form of an ellipse (Figs. 2002 and 2003). If too much tension is caused by such a closure a lateral incision may be made on either side of the wound (Fig. 2004). This lateral incision

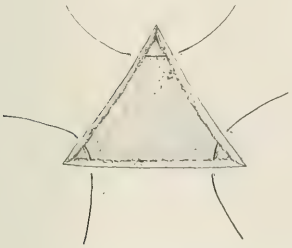


FIG. 2014.

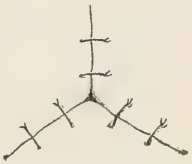


FIG. 2015.

FIG. 2014.—CLOSING TRIANGULAR WOUND AREA BY SUTURING FROM EACH CORNER.
FIG. 2015.—TRIANGULAR AREA CLOSED BY SUTURING FROM EACH CORNER.

FIG. 2016.

FIG. 2017.

FIG. 2018.

FIGS. 2016, 2017 AND 2018.—CLOSURE OF TRIANGULAR WOUND AREA BY AID OF ACCESSORY INCISIONS AND SUTURING FROM THE CORNERS.
After the wound is closed the accessory V-shaped wound is sutured as a Y.

FIG. 2019.

FIG. 2020.

FIG. 2021.

FIGS. 2019, 2020 AND 2021.—CLOSURE OF TRIANGULAR WOUND AREA BY AID OF SINGLE LINEAR ACCESSORY INCISION.
After closure of wound area, the accessory wound is sewed.

may be sutured, left open, covered with grafts, or closed by some other plastic method (Figs. 2005 and 2006). A small circular area, where a dimple or punctate scar is not objectionable, may be closed by a purse-string suture

(Fig. 2007) or as a Y or a cross (Figs. 2008 and 2009). This should not be used on the face as it must leave a scar.

A quadrilateral area may be closed by suturing from the four corners (Figs. 2010 and 2011). Such an area may be closed by converting it into

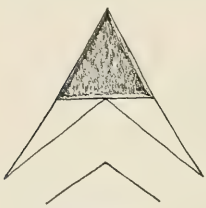


Fig. 2022.

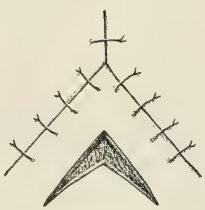


Fig. 2023.

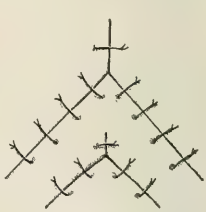


Fig. 2024.

Figs. 2022, 2023 and 2024.—Removal of Accessory Triangles to Facilitate Closure of Triangular Wound Area.

An additional angular incision is made, which later is closed as a Y.

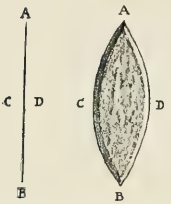


Fig. 2025. Fig. 2026. Fig. 2027. Fig. 2028.

Figs. 2025, 2026, 2027 and 2028.—Changing the Direction of a Longitudinal Wound.

The wound *AB* is spread apart; the lips *C* and *D* are grasped and drawn apart until the two extremities *A* and *B* approach and lie together at the middle of the wound. In this position it is sutured.

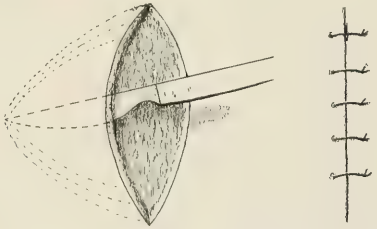


Fig. 2029.—Undercutting Skin to Permit Closure of Wound.

The undercutting is done on either side, which permits linear closure.

an ellipse (Fig. 2012), and making a single linear suture (Fig. 2013). A triangular area may be closed by the same method (Figs. 2014 and 2015). To all of these may be added the accessory lateral incision parallel with any

side (Figs. 2016, 2017, 2018, 2019, 2020 and 2021). Accessory triangles may be removed to facilitate closure (Figs. 2022, 2023 and 2024).

In order to relieve tension, to transfer tension from one direction to another or to change the contour of a surface, a simple longitudinal incision may be sutured as a longitudinal incision forming a scar, running at right angles to the first. This is done by drawing the sides apart and bringing the two ends together (Figs. 2025, 2026, 2027 and 2028).

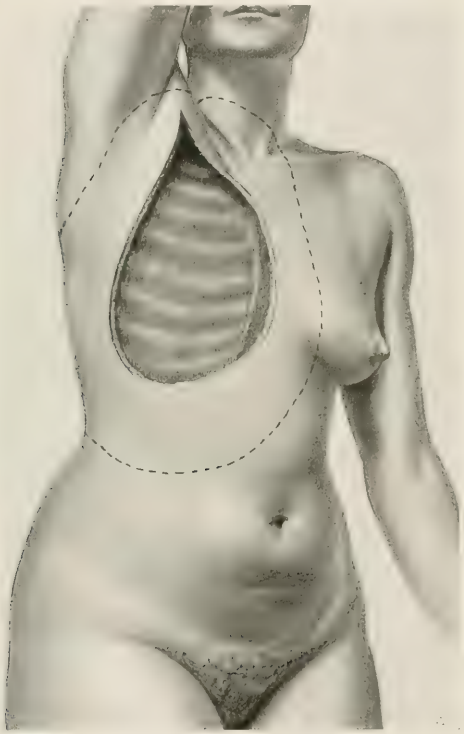


FIG. 2030.—SHOWING EXTENT TO WHICH UNDERCUTTING MAY BE CARRIED TO FACILITATE CLOSURE OF WOUND BY SLIDING SKIN FLAPS AFTER AMPUTATION OF BREAST.

2. **Undercutting the Skin.**—This is employed to allow greater lateral displacement than can be secured by depending upon the elasticity of the parts alone. Undercutting of the skin may be added to any of the operations described above. By this means the making of accessory incisions may be avoided. The undercutting may be done with a knife or scissors (Fig. 2029). There is no limit to the extent to which such undercutting may be carried (Fig. 2030).

3. **Sliding Flaps.**—This is an application of the principle of undercutting two flaps of skin. The simplest form of this operation consists in making an accessory incision in such a way as to liberate a flap which may

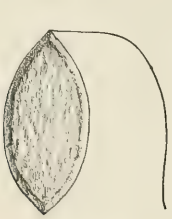


FIG. 2031.

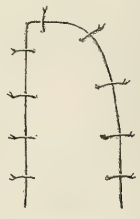


FIG. 2032.

FIG. 2031.—SINGLE SLIDING FLAP.

FIG. 2032.—SHOWING WOUND CLOSED BY SINGLE SLIDING FLAP.

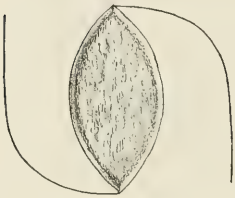


FIG. 2033.

FIG. 2034.

FIG. 2033.—DOUBLE SLIDING FLAPS.

FIG. 2034.—SHOWING WOUND CLOSED BY DOUBLE SLIDING FLAPS.

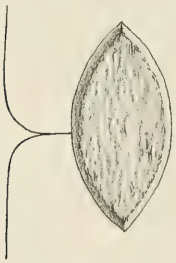


FIG. 2035.

FIG. 2036.

FIG. 2035.—DOUBLE UNILATERAL FLAPS.

FIG. 2036.—WOUND CLOSED BY DOUBLE UNILATERAL FLAPS.

be swung across the defect (Figs. 2031 and 2032). A double sliding flap is made in the same manner (Figs. 2033 and 2034). Either double (Figs. 2035 and 2036) or quadruple sliding flaps may be used (Figs. 2037 and 2038).

A quadrilateral defect may be covered by sliding a quadrilateral flap into it (Figs. 2039 and 2040). If the sliding flap cannot be made to fill the whole space similar flaps may be brought from other directions (Figs. 2041

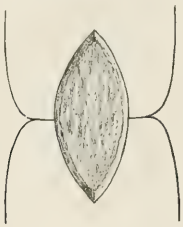


FIG. 2037.

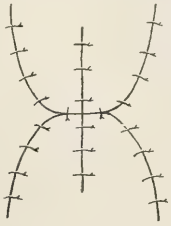


FIG. 2038.

FIG. 2037.—QUADRUPLE FLAPS.
FIG. 2038.—WOUND CLOSED BY QUADRUPLE FLAPS.

and 2042), or triangles may be removed to accommodate the displacement (Fig. 2043 and 2044).

A circular defect may be covered with sliding flaps the same as an ellipse. A triangular area may have one or two flaps slid over it (Figs. 2045, 2046,

FIG. 2039.

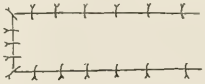


FIG. 2040.

FIG. 2039.—INCISION FOR COVERING QUADRILATERAL WOUND AREA BY SLIDING FLAP.
FIG. 2040.—QUADRILATERAL WOUND CLOSED BY SLIDING FLAP.

2047, 2048, 2049 and 2050). Triangular areas may also be filled by undermining a flap which slides into another triangular area (Figs. 2051 and 2052).

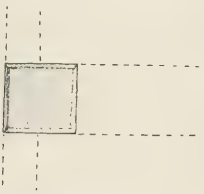


FIG. 2041.

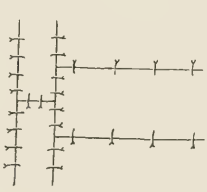


FIG. 2042.

FIG. 2041.—INCISIONS FOR COVERING QUADRILATERAL WOUND BY SLIDING FLAPS FROM THREE DIRECTIONS.
FIG. 2042.—QUADRILATERAL WOUND COVERED BY SLIDING FLAPS FROM THREE DIRECTIONS.

The removal of accessory triangles facilitates mobilization of flaps in some places (Figs. 2053 and 2054).

Sliding flaps are also used to cover the defect left by the removal of a flap (Figs. 2055 and 2056). Irregular areas may be covered by flaps shaped

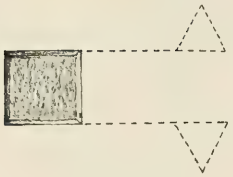


FIG. 2043.

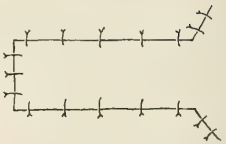


FIG. 2044.

FIG. 2043.—INCISIONS FOR COVERING QUADRILATERAL AREA BY SLIDING FLAP AND REMOVAL OF ACCESSORY TRIANGLES TO ACCOMMODATE THE DISPLACEMENT.
FIG. 2044.—WOUNDS CLOSED.
If the area is large the two triangles of skin may be preserved and applied to the quadrilateral area as grafts.

FIG. 2045.

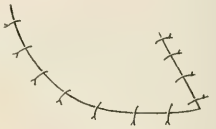


FIG. 2046.

FIG. 2045.—INCISION FOR COVERING TRIANGULAR AREA BY SLIDING FLAP.
FIG. 2046.—TRIANGULAR AREA COVERED AND WOUND SUTURED.

FIG. 2047.

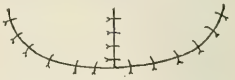


FIG. 2048.

FIG. 2047.—INCISIONS FOR COVERING TRIANGULAR AREA BY DOUBLE SLIDING FLAP.
FIG. 2048.—TRIANGULAR WOUND COVERED AND FLAPS SUTURED.

FIG. 2049.

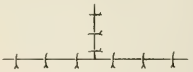


FIG. 2050.

FIG. 2049.—INCISIONS FOR COVERING TRIANGULAR AREA BY LATERAL FLAPS.
FIG. 2050.—TRIANGULAR AREA COVERED AND FLAPS SUTURED.

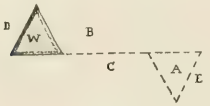


FIG. 2051.

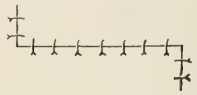


FIG. 2052.

FIG. 2051.—INCISIONS FOR COVERING TRIANGULAR AREA BY SINGLE SLIDING FLAP, MOBILIZED BY ADDING AN ACCESSORY TRIANGLE.
W, Wound area; *A*, accessory area to be removed; *B*, *C*, *D*, *E*, areas of skin to be undercut.
FIG. 2052.—RESULT AFTER CLOSURE OF TRIANGULAR WOUND BY REMOVING ACCESSORY TRIANGLE.

to meet the condition (Figs. 2057, 2058, 2059 and 2060). Flaps may be swung in from any part of the circumference of a wound area. In the face

Fig. 2053.

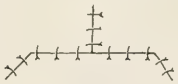


Fig. 2054.

Fig. 2053.—Closing Triangular Area by Removing Two Smaller Triangular Areas to Facilitate Mobilization.

A and *B* are the two areas to be removed; *W* is the wound area.

Fig. 2054.—Result after Closure of Triangular Wound by Removal of Two Accessory Triangles.

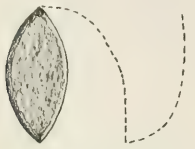


Fig. 2055.

Fig. 2056.

Fig. 2055.—Incisions for Secondary Sliding Flap to Cover Defect Left by Primary Flap.

Fig. 2056.—Wound Closed by Primary and Secondary Sliding Flaps.

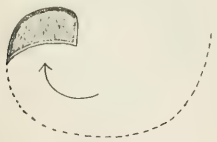


Fig. 2057.

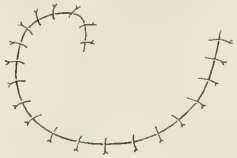


Fig. 2058.

Fig. 2057.—Incision for Sliding Flap to Cover an Irregular Area.

Fig. 2058.—Result after Closing Irregular Area with Sliding Flap.

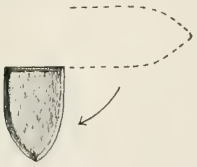


Fig. 2059.

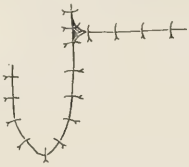


Fig. 2060.

Fig. 2059.—Incision for Covering Irregular Area by Swinging Flap.

Fig. 2060.—Result after Sewing Swinging Flap in Place.

especial selection must be made (Figs. 2061, 2062 and 2063). Sliding flaps may be mobilized by undercutting and removing an accessory triangle (Fig. 2064) (see Operations on the Face, page 655).

Fig. 2061.

Fig. 2062.

Fig. 2061.—Incision for Removal of Tumor of Upper Lip.
Fig. 2062.—Incision for Plastic Operation to Cover Defect of Upper Lip after Removal of Tumor.

Fig. 2063.

Fig. 2064.

Fig. 2063.—Showing Flap Swung into Defect from Below, Vermilion Border of Lip Restored, and Wounds Closed.
Fig. 2064.—Plastic Operation for Closing Defect after Removal of Epithelioma of Angle of Lips.

Fig. 2065.

Fig. 2066.

Fig. 2067.

Figs. 2065, 2066 and 2067.—Pedunculated Flap Used to Carry Skin from One Area to Another.

The problem is to cover the area *A* with skin from *B*, the blood supply being in the direction of the arrow. The flap *B* is placed on the area *A* and the flap *C* is trimmed to fit the area from which *B* is taken. The resulting wound is shown as *BC*.

4. **Pedunculated Flaps.**—A flap with a narrow pedicle is called a pedunculated flap. Such flaps are used in positions in which it is desired to transplant the total thickness of the skin for some distance and still retain its blood supply or to cover areas of a peculiar shape (Figs. 2065, 2066 and 2067). Large flaps can not be used. Pedunculated flaps are used also to cover an area by a flap taken from a distance, as from one leg to another, from the body to the arm, or from the arm to the face.

5. **Reversing a Pedunculated Flap.**—This is done in situations in which it is desired to cover a surface which rests against the skin of another surface.

6. **Making a Bridge of Skin for Transplantation.**—This operation consists in making two parallel incisions, undercutting the skin between them, and sliding the area to be covered under the bridge (Fig. 2068).

H.J.S

FIG. 2068.—BRIDGE TRANSPLANTATION.

Showing the possibilities of taking skin from the trunk to cover surfaces on the upper extremity. The uppermost flap illustrates the method of taking skin from the back of the arm to cover a denuded area on the chest. After healing has been secured the flaps are cut free from their natural connections.

7. **Turning in a Skin Surface to Take the Place of Mucous Membrane.**—This is done in defects of the mouth, bladder, vagina and other hollow parts requiring reconstruction. A skin flap is turned in and the skin is sutured continuously with the mucous membrane. If a raw side of the flap faces outward it is then covered by another flap with the skin outward. This operation will be described under local operations.

8. **Massive Skin Transplantation.**—It is possible to cut out the whole thickness of a piece of skin with subcutaneous tissue, and transplant it. In doing this absolute asepsis is essential. The smaller the area the better the chances of success. Large areas cannot be treated in this way. Areas as large as 8 or 10 cm. (3 or 4 inches) in diameter may be covered. The area upon which the graft is to be placed should be either a fresh surface

or recent granulations. If the granulating surface is old and has much underlying connective tissue, sufficient blood supply will not develop for the nourishment of the graft. The graft should exactly fit the space to be covered. In cutting it an allowance should be made for losing one-third of its size by shrinkage after it is detached. The surface to be covered should be free from clots. The graft should be sewed in place, covered with a soft dressing, and the part immobilized. If no infection is present, plastic exudate glues the graft to its new bed, young blood-vessels from the raw surface penetrate it, and it develops a circulation. Its cells do not die, but remain alive by virtue of the moisture and nourishment which the graft contains, and the heat which the body supplies.

Skin-grafting.—This operation consists in transplanting a thin layer of the outer part of the skin, leaving behind the deeper parts of the papillæ to regenerate new skin. An area of any size may be covered by skin-grafts.

The preparation of the raw surface is important. The less it contains of old connective tissue, the better the assurance of success. Surfaces, such as old ulcers, having a hard bed of scar tissue do not sustain grafts well. In such cases it is best to excise the cicatricial bed, and graft upon tissue having a better blood supply. The best results are secured in grafting upon recent succulent granulations or immediately upon a fresh wound surface. In the case of a surface on which granulations have been growing for but a short time, but still are exuberant, the granulations should be shaved off with a sharp knife just preliminary to grafting. No necrotic tissue should be present All bleeding should be stopped, and clots washed away. Bleeding may be checked best by covering the surface with oiled or rubber protective and making pressure upon it. If gauze is used, it leaves particles of cotton, clots adhere to it and bleeding recurs when the gauze is removed.

For preliminary sterilization of a granulating surface to be grafted, a daily dressing for boric acid solution, applied in a copious mass of sterile gauze, should be used for four or five days before the operation. On the day preceding operation sterile salt solution should be substituted for the boric acid. Or the granulations may be cleansed, dried, painted with iodin, and dressed with balsam-of-Peru (1 part) and castor oil (3 parts).

The area from which grafts are to be taken should be cleansed and dressed with boric acid solution on the day before operation. Before cutting the grafts the skin should be washed off with sterile salt solution. Instead of washing tincture of iodin may be used to sterilize the skin. It seems not to harm the grafts.

For ordinary purposes the outer side, front, and inner side of the thigh furnish the best skin. Grafts may be taken from the upper arm or any other part of the body.

For cutting grafts from a large area or from a nervous person general *anesthesia* is desirable. Smaller areas may be anesthetized by injecting 1 per cent. quinin and urea hydrochlorid solution, or 0.5 per cent. novocain solution, or by nerve blocking. Local ethyl chlorid may be used; it produces anesthesia; the stiff tissue cuts easily; and the freezing does not seem to destroy the vitality of the grafts (Fig. 2069). When quinin and urea are used the solution should not be injected into the graft area as it interferes with healing.

A very sharp razor is used for splitting the superficial part of the true skin from the deeper papillary layer. The razor and the skin should be moistened with salt solution by an assistant who permits a gentle flow of solution upon the field of operation. The surgeon makes the skin tense by laying the palms of the fingers of the left hand upon it and pressing toward

the ulnar side. The razor in the right hand is placed nearly flat upon the skin about 2.5 cm. (1 inch) above the index-finger of the left hand and paral-

Fig. 2069.—Anesthetizing Outer Side of Thigh for Cutting Skin-grafts.

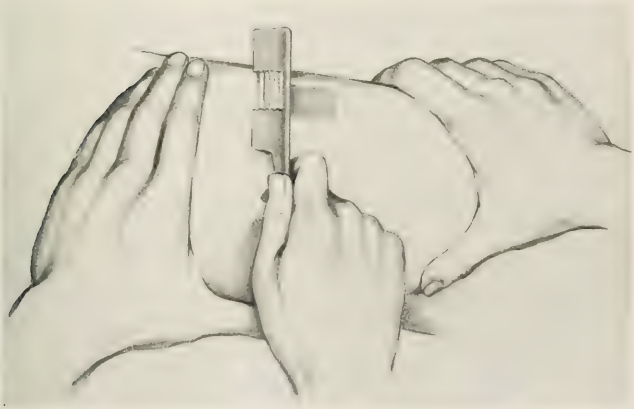


Fig. 2070.—Cutting Grafts from Anesthetized Area on Thigh.

lel with it. A back and forth sawing motion causes the razor to enter the skin while the left hand keeps the skin tense and slides along just in front of the razor (Fig. 2070).

The assistant keeps the skin slightly moist with salt solution, so that the surgeon's left hand slides easily and the graft does not stick to the razor; and with his other hand makes traction back of the razor against the traction made by the surgeon. Occasionally it may be necessary for the assistant to straighten out the graft with anatomical forceps to prevent it folding up in front of the cutting edge of the razor. As the graft is cut it should accumulate in folds upon the surface of the razor or fall over back of the razor as the latter glides under it.

If the area is large, grafts 10 or 13 cm. (4 or 5 inches) long and 2.5 to 5 cm. (1 to 2 inches) wide should be made. The area to be covered should be ready to receive the graft as soon as it is cut. The razor, with the graft lying on it, should be transferred to the prepared surface, which should be dry and free from excess of salt solution and blood. The end of the graft is caught with

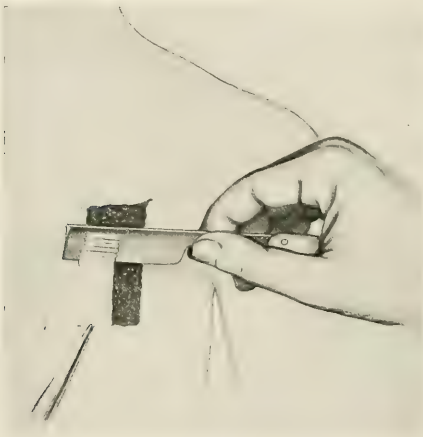


FIG. 2071.—PLACING GRAFTS ON WOUND AREA.

The graft is carried on the razor with which it is cut. It lies in folds. One end is grasped with anatomical forceps and gently pulled from the razor as the latter is drawn along over the wound area.

forceps and held while the razor moves from under it and slides it off (Fig. 2071). As the surgeon returns to cut the next graft an assistant smooths out the graft with anatomic forceps. The whole surface should be covered. Each graft should lie closely to its neighbor. Bubbles of air under the graft should be pressed out. The grafts should be gently pressed upon to cause them to adhere. After they have been closely pressed in place and adhere, they may be left uncovered until the last graft is placed (Fig. 2072).

If a number of grafts are to be cut the first should be taken from the most dependent area in order that, as succeeding grafts are cut, the blood from the skin wounds shall not be flowing over the field of operation.

Grafts such as this may be applied not only to granulating surfaces, but to cancellous tissue, muscle, periosteum, bone and fatty tissue. Grafts do not do well if placed on old or thick granulations. The fresh wound is

best for grafts. Denuded bone which is dry and offers no nourishment for grafts, may be covered with granulations by boring holes in the outer table. This causes islands of granulations to spring up. The best results are secured when the whole area is covered and no tissue shows between the grafts. As the grafts shrink slightly, it is well to allow their edges to overlap. It is perfectly good surgery to place them about as isolated islands or to leave a space between them.

Instead of the ordinary razor, special knives are made for this purpose. Pressure with a gauze compress should be made upon the wound from which the graft was cut to check bleeding. In order to cut grafts which have parallel sides, two paralled incisions part way through the skin may be made before the graft is cut. Instead of using the flat of the hand to make the skin tense some surgeons use special hooks which are made for this purpose. A

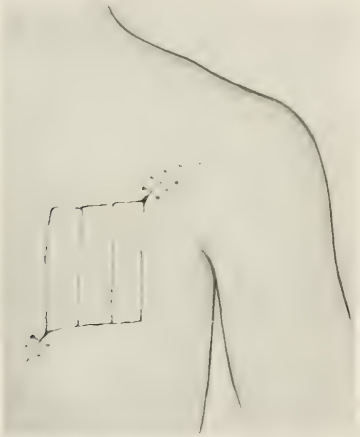


FIG. 2072.—AREA OF WOUND COVERED WITH GRAFTS

flat piece of board is sometimes used. A surgeon who is skilled in this operation needs no apparatus but an ordinary razor and his hands. The section-cutting (microtome) razor may be used.

The *dressing of skin-grafts* is most important. It should make even and gentle pressure; it should immobilize the parts; exudate should be absorbed; and the dressing should not adhere to the grafts if it has to be removed before the seventh day. Coarse-meshed gauze or other coarser cloth which has been treated with paraffin, and sterilized serves best for the covering to lie against the grafts. One layer of this should be fixed to the skin by adhesive strips or collodion (Fig. 2073). It may be covered with ordinary gauze. The under layers of the gauze dressing should extend only to the edge of the grafted area. It should be placed flatly. Over this should be another gauze dressing held by adhesive straps and bandage (Fig. 2074). A muslin bandage should then envelop the whole dressing.

If the grafts have been applied to a limb, it should be immobilized by a

splint. This gauze next to the grafts should be left on for ten days. The gauze external to the under layer should be changed about the second day or sooner if indicated. The deeper layer of gauze should be changed earlier than the tenth day only if discharges show that infection has occurred or the grafts are necrotic.

Other materials which are applied next to the grafts are rubber protective, oiled silk, silver foil, sterilized powder and ointment. When impervious fabrics are used strips should be employed, or the sheets should be perforated with holes.

I have noticed that when all of the grafts did not adhere, those which did the best were the grafts that were first applied, and which had dried in the air before the dressing was put on. In some cases I have secured perfect results by using no dressing at all.

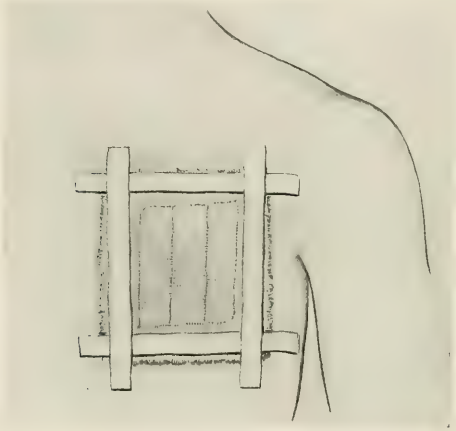


FIG. 2073.—DRESSING OF SKIN-GRAFTS.

A single layer of coarse gauze, impregnated with paraffin, is placed over the grafts and fixed to the surrounding skin with adhesive strips.

Grafts treated without dressing are allowed to become dry. The slight discharge from the uncovered granulations dries. The grafts should be protected from injury by a wire cage or frame, which should prevent the bed clothes or other objects from disturbing them. The whole surface should be exposed to the light and the air.

A. S. Vosburg (Annals of Surgery, vol. 55, 1912, page 891) reported excellent results with adhesive plaster dressing. He used zinc oxid adhesive plaster strips which had been sterilized by formalin vapor. The strips are placed close together leaving a small interval through which secretions may escape. A gauze dressing is placed over this, and changed as often as necessary. Ointment may be used to prevent the gauze adhering to the strips of plaster. The strips are left in place for six or eight days.

Some surgeons dress the grafts with gauze saturated with salt solution and change the dressing daily. This must be done with the greatest care

as movement of the grafts disturbs their vital connections and causes them to die. It has not given as good results in my hands as the dry dressings or ointment.

A satisfactory covering is bismuth subnitrate powder with dry gauze. Sterilized vaselin or bismuth ointment, smeared on dry gauze is a useful dressing.

A dressing favored by French surgeons is taffeta, smoothly placed over the grafts, and covered by a compress of cotton or gauze. The taffeta is thin, smooth, and light, and does not stick to the tissues.

It should be remembered that the superficial skin layer exfoliates. After this has come away the deeper part of the graft should remain. The surgeon

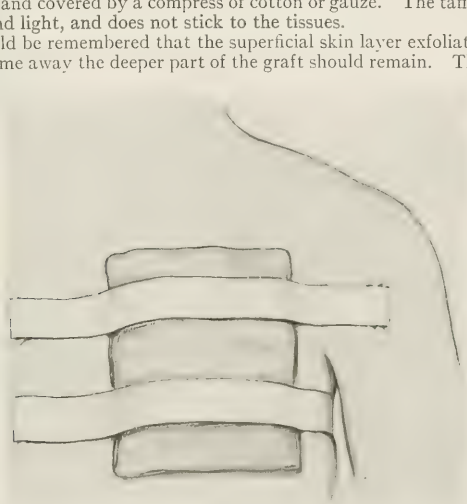


FIG. 2074.—COMPLETED DRESSING OF SKIN GRAFTS.

A gauze dressing, applied over grafted area to make gentle pressure, immobilizes the tissues, absorbs serum, keeps the skin warm, and protects the grafts from mechanica injury.

should not assume that the graft is not successful because of the superficial exfoliation. Only when the whole thickness of the graft becomes detached may it be assumed that the grafting has failed. Sometimes a part of the grafts fails to adhere, but if some islands of new skin remain here and there much has been accomplished, as they serve for centers from which skin growth takes place.

The area from which the grafts were taken should be dressed with a thick layer of sterile ointment to prevent adhesion of the gauze.

If grafts are placed upon an area which is surrounded by skin having a layer of fat or a layer of areolar connective tissue under it, in the course of time similar tissue will develop under the new skin.

Skin-grafts do best when taken from the individual upon whom they are to be transplanted. If for any reason the patient can not furnish his own grafts then they are best taken from the nearest blood relation—father, mother, brother or sister. Grafts may be taken from other non-related persons. An amputated limb is always a fruitful source of grafts. Skin

from the recently dead, provided no infective disease is present, may be employed. But none of these sources furnish grafts which have so good a chance of living as grafts from the patient himself.

Free grafts of the whole thickness of the skin are especially useful in the *treatment of contractures*. In contractures following burns, ulcers, sloughs and wounds, the contractured tissues may be dissected away and skin transplanted with most happy results. Before the operation the contractured region should be massaged twice daily for several days to increase the mobility of the tissues and improve the blood supply. The contractured skin and underlying scar tissue should be removed. When not all of the scar tissue can be excised, the part should be put up on a splint, so padded and arranged as to counteract the contracture.

Before placing the graft the wound surface should be perfectly dry. If oozing can not be checked it is better to wait a day before applying the graft than to invite failure by placing it on a bleeding or bloody surface. Whole thickness skin-grafts may be placed on granulating surfaces. If the skin has much fat under it, the excess of fat should be cut off with curved scissors after the graft has been cut. A graft loses about one-third of its area by shrinkage. Large grafts should have holes cut in them to permit the escape of secretions. Sutures of fine silk or horsehair are used to hold the graft in place. Small grafts placed on dry surfaces will adhere without suturing. For dressing whole skin-grafts the same materials as are used for cuticular grafts may be employed. Moist salt gauze, dry gauze or silver foil also are useful.

Immobilization of the parts is essential. The dressing should be secured with adhesive straps or with paraffin coating. A splint should be applied to immobilize the muscles and neighboring joints.

Previously prepared grafts have been used with success. Such grafts are taken from other persons at times of operation or shortly after death or amputation of a part. The skin is dried and sterilized with tincture of iodin, which is then washed away with alcohol, followed by sterile salt solution. For convenience the grafts are cut in pieces about 2.5 cm. (1 inch) square. The whole thickness of the skin is used exclusive of subcutaneous connective tissue. These squares are kept at body temperature on nutrient gelatin, such as used for cultivation of bacteria. If infection is present they spoil. If they have been taken and planted under aseptic conditions they remain viable for many days, and may be washed in warm salt solution and grafted just as fresh grafts. Another method of preserving grafts is in cold storage at a temperature just above the freezing-point.

Blister grafts are secured by blistering the skin and transplanting that part which is lifted up by the serum. Some surgeons have reported good success with this method. I cannot recommend it.

Zoödermic grafting has been used with some success. Skin of dogs, rabbits, cats, and pigeons has been employed. The hair is shaved off and the skin rendered sterile. Grafts may be taken with a razor or the whole thickness of the skin may be used. Before taking the grafts the animal may be anesthetized or killed. The grafts are dressed as described above. In the course of time hair ceases to grow and the area takes on the character of the surrounding skin. Skin from the back of the frog is said to have been used with success.

Skin taken from the negro seems to do especially well. When negro skin is grafted upon the white race it looses its pigment. It is said that white skin grafted on the negro does not take so well; when the grafts live, they become pigmented like the surrounding skin.

Flocculent grafts are secured by wetting the skin with salt solution and then scraping or shaving it with a razor in such a manner that fine particles of skin are collected on the razor in a wet mass like porridge. This mass is distributed over the raw area and pressed down by a dry dressing. Islands of epithelium are visible in a few days.

Punctate grafting consists in dotting a raw surface with minute islands of epithelium. These islands may be cut by picking up the skin on the point of a needle, thrust through it, and cutting off the little point thus lifted up. By using a very sharp knife a piece of skin 2 or 3 mm. in diameter is removed, transfixed by the needle (Fig. 2075). Or the skin may be punctured simply once with a long straight needle lifted up and the graft cut. This may be done rapidly, and the grafts placed in rows with a distance of 0.5 cm. be-

FIG. 2075.—CUTTING PUNCTATE GRAFTS.

A needle, held in a hemostatic clamp pierces the skin, and a sharp knife cuts free the little graft.

tween each graft (Fig. 2076). The graft is conveyed at once to the raw surface to be grafted and pressed in place by another needle with its epithelial side uppermost. A multitude of such islands may be planted over a granulating surface. Paraffin mesh may be applied or a strip of rubber protective may then be laid over each row with a space between, thus providing for free escape of discharges. Over all should be placed a gauze dressing held with adhesive strips.

Around a granulating area will be seen a zone of bluish new skin. Grafts may be taken from this in the above manner without pain.

Intracellular grafting consists in picking up a point of skin surface with forceps, to make a little cone, truncating the cone with a sharp knife, and then pressing the little piece of skin which remains in the grasp of the forceps deeply into the granulations of the surface requiring the grafting. The skin surface from which the grafts are taken may be anesthetized locally. The grafted area is dressed as above.

Tunnel skin-grafting consists in cutting from a piece of excised skin strips of skin about 6 mm. (¼ inch) wide and about 2 cm. (¾ inch) long; a narrow knife is pushed under the granulations to be grafted making a tunnel about 2.5 cm. (1 inch) long; narrow forceps are then passed through the tunnel, opened slightly, and caused to grasp the end of a graft, which is pulled into the tunnel. Both ends of the graft should be covered. Any number of such grafts may be inserted. After a few days when the grafts have become adherent the overlying tissue is cut and the graft exposed. This method was first described by A. Mac Lennan (Glasgow Med. Jour., August, 1912)

Dermo-epidermic grafting was first described by Reverdin. The granulating surface is scooped out by means of a small curet. Little excavations about 8 or 10 mm. wide are made. The bottom of these cups is the fascia under the granulations. Into these cavities little grafts 6 or 8 mm. in size,

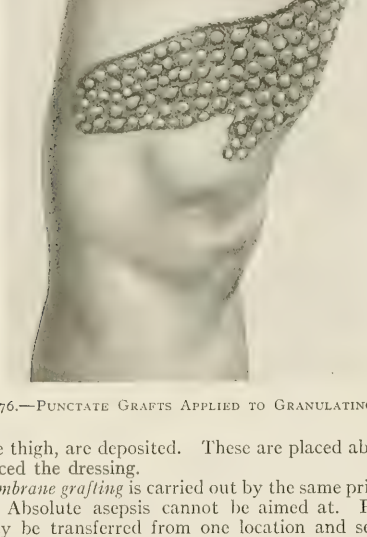


FIG. 2076.—PUNCTATE GRAFTS APPLIED TO GRANULATING SURFACE.

taken from the thigh, are deposited. These are placed about 1.5 cm. apart. Over all is placed the dressing.

Mucous membrane grafting is carried out by the same principles as massive skin-grafting. Absolute asepsis cannot be aimed at. Patches of mucous membrane may be transferred from one location and sewed into another with good hope of success. Such patches may be kept for many days in cold storage before being used, or immediate transfer may be made.

E. Lexer (Med. Klinik, Nov. 19, 1911) resected a sound vermiform appendix, stripped it of its serosa and outer muscular layer, and used it to replace the lost mucous membrane of the urethra in a gap of 8 cm. (3 inches). The graft was sewed at its upper end and the lower end drawn forward through the urethra. It grew perfectly and provided a smooth mucous lining.

Grafting of hairy skin is done where hair is needed in a new position,

such as eyebrows or mustaches. Skin for this purpose may be taken from the hairy scalp, the pubes or hair-bearing parts of the face. The skin to be transplanted should be shaved of hair, and the whole thickness of the skin transferred. The direction of the growth of the hair should be considered.

Grafting of Other Tissues.—*Free transplantation* is not confined to skin alone. Nearly every tissue of the body is susceptible of being transplanted. Muscle is the most difficult to deal with as it becomes converted into fibrous tissue unless the vessels and nerves are preserved, and circulation and innervation reëstablished.

Bone-grafting has been discussed under Operations on Bones and Joints (Vol. I, pages 688 and 772).

Nerve-grafting succeeds only as the implanted nerve serves as a scaffolding upon which new nerve may develop (see Operations on Nerves, Vol. I, page 852).

Fascia-grafting, if carefully done, is successfully used to reinforce operations for hernia, fractures, to fill bone defects, defects of the chest wall, to

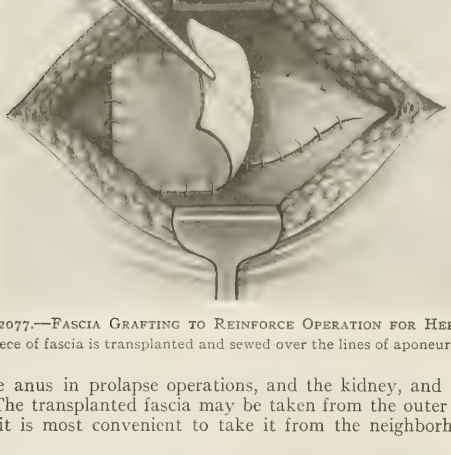


FIG. 2077.—FASCIA GRAFTING TO REINFORCE OPERATION FOR HERNIA.
A detached piece of fascia is transplanted and sewed over the lines of aponeurosis suturing.

hold up the anus in prolapse operations, and the kidney, and to elongate tendons. The transplanted fascia may be taken from the outer side of the thigh, but it is most convenient to take it from the neighborhood of the operation.

Fascia-grafts may be used as a *wrapping for fractures*, to form a case or ferrule to hold the bone-ends together. Especially in fractures of the humerus are such grafts useful. Such a strip may be wrapped once or twice around the bone and tightly sewed in place. It serves as a preliminary callus or periosteum.

When used to reinforce *hernia*, the graft may be placed beneath the local fascia or superimposed upon it (Fig. 2077).

For reinforcing the tissues in front of the knee in *old fracture of the patella* with wide separation, D. B. Phemister (Annals of Surg., December, 1915) successfully employed a fascia-graft (Fig. 2078).

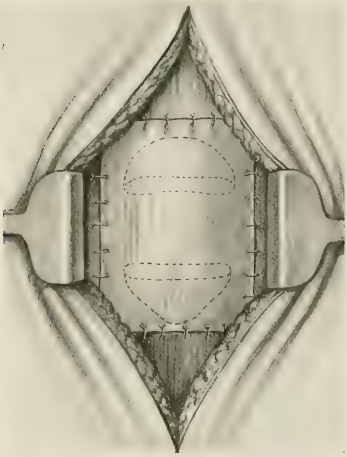


FIG. 2078.—FASCIA GRAFT USED TO REINFORCE EXTENSOR TENDON IN CASE OF OLD FRACTURE OF THE PATELLA.

A transplanted piece of fascia is sewed over the torn and stretched patellar fascia.

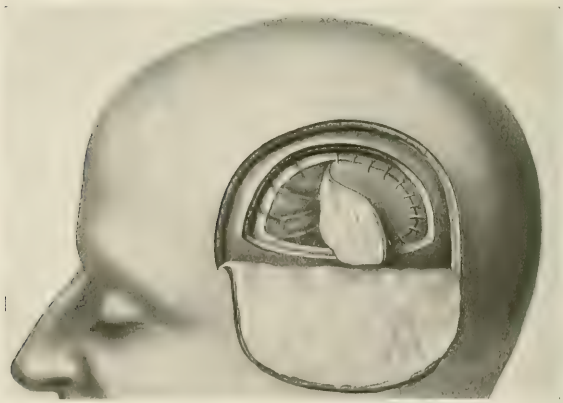


FIG. 2079.—FASCIA GRAFT USED TO REPLACE DEFECT OF DURA MATER.

Fat is taken with the graft and placed against the pia mater.

Defects of *dura* may be supplied by a fascia-flap. A. A. Law (Annals of Surg., November, 1915) illustrated the use of such a flap with fatty tissue left on one side. The fat is placed next to the pia (Fig. 2079).

Law also showed how the *loss of tendon* may be restored by means of a piece of fascia inserted to take its place (Fig. 2080).

L. Freeman (Annals of Surg., May, 1915) upon the assumption that the formation of *keloid* in a scar of the neck is due to the tension of the wound, excised the keloid, transplanted a piece of fascia which was spread out under the skin wound, and secured healing without the recurrence of keloid.

For *joint reconstruction* fascia is especially valuable if the overlying fat is taken with it. The fascia lata, containing the trochanteric bursa is most useful for interposition in the treatment of ankylosed joints. For any purpose requiring fascia, the strong iliotibial band, lying along the outer side of the thigh is to be preferred. It is desirable in joint reconstruction that a good thickness of tissue shall be interposed between the bones; and for this purpose nothing serves better than two layers of fascia lata with the adjacent subcutaneous fat, the two fat surfaces being folded together.

Fascia grafts are described and operations are illustrated under the respective heads in which they are employed (see Operations on Nerves, Tendons, Bones, Joints, Hernia, Stomach and Intestines).

Mucous-membrane grafting succeeds when tissues containing mucous membrane are used, such as the appendix; but grafts of pure mucous membrane are difficult to implant. This is because of the presence of infection and maceration in mucous membranes.

Muscle cannot be expected to live when transplanted unless its nerve supply is preserved. This is very difficult. It is useful sometimes to fill bone cavities, where it becomes changed into fatty and connective tissue.

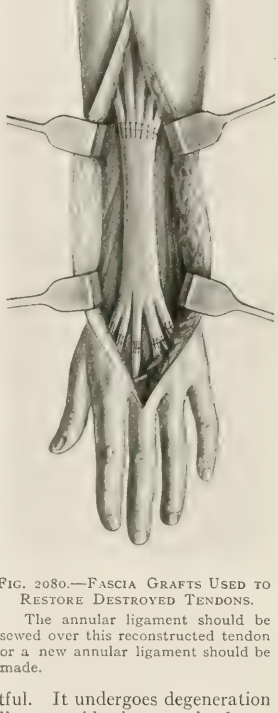


FIG. 2080.—FASCIA GRAFTS USED TO RESTORE DESTROYED TENDONS.

The annular ligament should be sewed over this reconstructed tendon or a new annular ligament should be made.

Nerve tissue may be transplanted to fill a defect in a nerve, but its fate is doubtful. It undergoes degeneration and serves the same as a connective scaffolding to guide the growth of new nerve cells (see Nerves).

Blood-vessel transplantation is highly successful. Pieces of vein are used to fill the defect in continuity of a functionating vein. E. Lexer first did this in 1907, when he resected an aneurism of the axillary artery and restored the continuity of the vessel by inserting a segment of saphenous vein. Pieces of vein may be used to restore the continuity of the urethra. Segments of

vessels have been used to drain hydrocephalus to carry the ventricular secretion into the venous circulation (see Blood-vessels).

Tendon transplantation is discussed under tendons. Adhesions should be prevented by wrapping a fat graft about the tendon or by passing it through a tunnel in fatty tissue.

Peritoneum may be taken from hydrocele sac and hernia sac for covering in defects of the dura. It serves well, but is prone to adhere to the pia or brain. Fat is much better. Peritoneal grafts are especially useful in making a sheath for tendons or nerves. It may be interposed in joints to furnish new synovial membrane. It is useful to reinforce the suturing of blood-vessels. Of course its natural use is to supply missing peritoneum.

Cartilage is used to replace loss of cartilage and to fill defects. It is especially useful in reconstructions of the nose and ear. It is taken from the ribs to the best advantage.

Joint transplantation is discussed under Bones and Joints.

Fat-grafting has been employed to give plumpness where it was desired for *cosmetic* purposes. It is very useful in filling hollows of the face, and has much to recommend it in place of paraffin. A clean lobule of fat taken from the abdominal wall or elsewhere is buried under the skin and the wound closed. A lipoma has been taken from the back and planted under the skin of the breast to take the place of an amputated mammary gland.

The wound through which the fat is introduced need not be large. The skin should be dissected free to make a pocket for the reception of the fat. It should not be introduced until all bleeding has stopped. It can be introduced in one or several pieces, in masses large enough to restore contour or fill cavities. It remains permanently.

A flap or pad of fat, taken together with the subcutaneous tissue, and placed in a cavity in which bleeding has been completely checked, may be expected to live, particularly if the asepsis is complete and the suture line does not lie upon it. Such flaps are useful to fill out depressions of the face, to restore the breast after amputation, and to fill the orbit after enucleation of the eyeball. Fat as a *filling for bone cavities* is discussed under bones. A most useful field is in joints to prevent adhesions, and to restore motion after operations for *ankylosis* (see Joints). To *protect nerves* and *tendons* from adhesions and injury a surrounding graft of fat or areolar tissue is most useful.

Nothing serves so well as a fat-graft to fill a *defect of the dura* where there is injury of the pia or brain. Fascia, without fat becomes adherent on both sides, but fat closes the defect, and leaves the brain movable and free.

Omentum is a most valuable form of fatty tissue for forming adhesions. It is especially useful to cover peritoneal defects where adhesions are desired.

The transplantation of fat *to prevent adhesions of scars* and restore mobility is accomplished by dissecting free the scar from the underlying structures and interposing a layer of fat. This operation is especially effective for releasing tendons and scar tissue such as forms in the palm of the hand after acute infections. Fat placed about vessels *to prevent edema* is useful in wounds in which the large vessels of a limb have been exposed and are destined to be surrounded by scar tissue.

Transplantation of Organs and Parts.—This is one of the triumphs of modern surgery and has been made possible only by the discovery of aseptic technic. Sections of *veins and arteries* have been transplanted from one animal into the vessels of another with perfect success. A segment of the carotid artery of a dog has been removed, kept in cold storage for twenty

days, and then successfully implanted into the aorta of a cat (see Suture of Arteries).

The *vermiform appendix* has been used to reconstruct the urethra and ureter. A segment of vein has been employed for the same purpose. A segment of saphenous vein has been used successfully to restore the femoral artery after excision for aneurism.

Transplantation of the *thyroid* and *ovaries* has been discussed in its place under those organs. The transplantation of the former gland has met with signal success. *Suprarenal glands, parathyroid bodies* and the *spleen* have been transplanted. Animals have been subjected to *nephrectomy,* and the kidneys of another animal of the same species have been transplanted and caused to functionate for several weeks. The *heart* has been removed from a dog, its vessels anastomosed with the vessels in the neck of another dog, and the heart has functionated for a short time.

The transplantation of *teeth* has long been practised (see Jaws and Mouth).

For patching defects in arteries and veins not only has like tissue been used but peritoneum and even adipose tissue have been successfully employed.

Transplantation of amputated members has been successfully performed. The legs of dogs have been amputated and transplanted to other dogs. This is done by anastomosing the main blood-vessels, uniting the main nerve trunk, suturing the tendons and skin and applying a splint to keep the bones in apposition.

Amputated fingers have been replaced and caused to grow. The great toe of a man has been removed and transplanted upon the stump of an amputated thumb by Krause. The operation was begun by dorsal resecting the head of the metatarsal bone of the toe. The stump of the thumb was then freshened and sewed to the base of the toe, the plantar structures not being divided. The tendons were united; blood-vessels were too small for anastomosis; the skin was sutured; and the hand and foot were bound together and held in a plaster-of-Paris dressing for seventeen days. The dressings were then removed, the plantar structures divided and the amputation completed. The palmar and plantar tissues were then sutured and a fairly successful cosmetic effect secured.

For immediate restoration of amputated fingers, see Operations on the Upper Extremities (page 786).

PLASTIC OPERATIONS ON THE HEAD

Operations on the Eyes.—(See Eye, Vol. II, page 138.)

Operations on the External Ear.—*For restoring absent external ear* many operations have been devised. Grafting a whole ear offers so little hope of success that it is scarcely worth while sacrificing a good ear for this purpose. It is possible that with the use of the vacuum suction cup and heated applications, success may be secured. For this purpose, however, ears should be taken from the recently dead rather than from the living, while the operation is still experimental (Fig. 2081).

It is possible to build up an ear by plastic methods, if the surgeon and patient are capable of great patience. A double flap is taken, after the incision devised by Szymanowski, from the side of the head, which when folded in place reproduces an auricle (Figs. 2082 and 2083). After this flap has been cut and dissected up the posterior crescentic part is folded internal to the anterior part and sutured back of the ear. The raw area remaining should be covered by sliding flaps of scalp and by skin-grafts. Not too much should be attempted at each operation. At subsequent operations the upper

and lower segments of the ear should be freed (Figs. 2084 and 2085). The lobe is shaped by further plastic (Figs. 2086 and 2087). The helix is formed

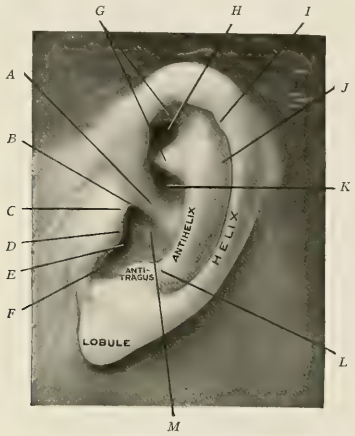


FIG. 2081.—THE EXTERNAL EAR OR AURICLE.

A, Crus of helix; *B*, incisura anterior; *C*, tuberculum supratragicum; *D*, tragus; *E*, external auditory meatus; *F*, incisura intertragica; *G*, crura of antihelix; *H*, fossa triangularis; *I*, darwinian tubercle; *J*, scaphoid fossa; *K*, cymba conchæ; *L*, posterior auricular sulcus; *M*, cavum conchæ.

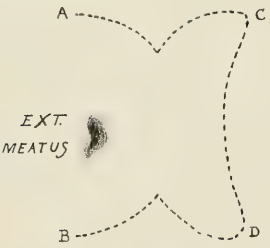


FIG. 2082.

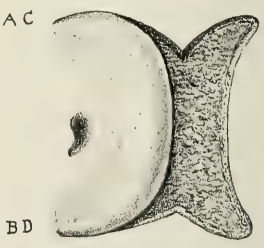


FIG. 2083.

FIG. 2082.—INCISION FOR RECONSTRUCTION OF AURICLE.

This operation is done in cases in which the auricle is missing and the external auditory opening is the only visible ear.

FIG. 2083.—OPERATION FOR RECONSTRUCTION OF AURICLE.

The flap *CD* is folded internal to *AB* and sewed in place along the lines *AC* and *BD*. The area behind the ear from which the flap is taken is covered by plastic sliding flaps and skin grafts.

by resecting a narrow strip and suturing its skin edges through in a manner to make the border of the ear roll outward (Fig. 2088).

This operation may be continued indefinitely, shaping and modeling

the ear, as there will always remain room for improvement. At some stage of the operations, narrow strips should be taken from the costal cartilages, or from the ear of the recently deceased, and inserted into canals in the ear

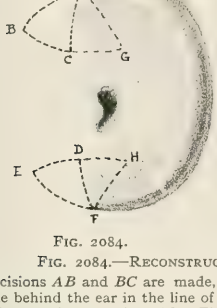


FIG. 2084.

FIG. 2085.

FIG. 2084.—RECONSTRUCTION AND SHAPING OF AURICLE.

The incisions *AB* and *BC* are made, and the flap *ABC* is dissected up. The incision *AG* is made behind the ear in the line of suture of the original crescentic flap, and the ear dissected free in the triangle *ACG*. The flap *ABC* is then turned back, wrapping around the border of the ear at *AC*, and the line *AB* is sutured to the line on the ear at *AG*. The raw area *ABG* on the side of the head is covered by skin grafting. At a later operation the same procedure is carried out below to form the lobe of the ear. The result after the operations outlined is shown in the following.

FIG. 2085.—RECONSTRUCTION AND SHAPING OF EAR.
Result after preceding operation.

made by a narrow knife. The openings into which the strips of cartilage are pushed should be closed by a suture. The positions of the cartilages should correspond with the positions of the normal cartilages of the ear. Bone may be substituted for cartilage at the upper part of the ear. Unless

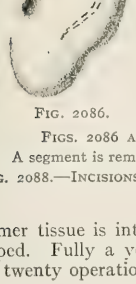


FIG. 2086.

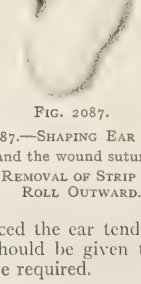


FIG. 2087.

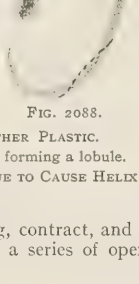


FIG. 2088.

FIGS. 2086 AND 2087.—SHAPING EAR BY FURTHER PLASTIC.
A segment is removed and the wound sutured, thus forming a lobule.

FIG. 2088.—INCISIONS FOR REMOVAL OF STRIP OF TISSUE TO CAUSE HELIX TO ROLL OUTWARD.

this firmer tissue is introduced the ear tends to sag, contract, and become misshaped. Fully a year should be given to such a series of operations. Ten or twenty operations are required.

For *restoring parts of the ear* the same principles are applied. Tissue may be taken from the side of the head; or from the arm by the flap method, the arm being bound to the head after the manner of Tagliacozzi.

For *reducing the size of the ear*, Schwartze devised a successful operation. A crescentic and a triangular segment of the entire thickness of the ear

Fig. 2089.

Fig. 2090.

Figs. 2089 and 2090.—Operations for Reducing Size of Ear. Method of Schwartze.

are removed from the positions where reduction in size is desired. This operation may be done at more than one location (Figs. 2089 and 2090). Other operations have been devised by Parkhill (Figs. 2091 and 2092) and Kolle (Figs. 2093 and 2094).

Lop-ear is the condition in which the ears stand out with undue prominence, and should be prevented in infancy by holding the ears close to the

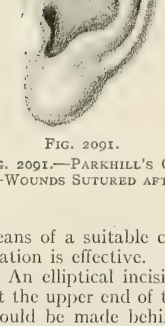


Fig. 2091.

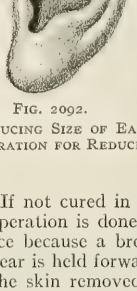


Fig. 2092.

Fig. 2091.—Parkhill's Operation for Reducing Size of Ear.
Fig. 2092.—Wounds Sutured after Parkhill's Operation for Reducing Size of Ear.

head by means of a suitable cap or bandage. If not cured in this way a simple operation is effective. The earlier the operation is done the better the result. An elliptical incision does not suffice because a broad base is necessary at the upper end of the wound. The ear is held forward and the incisions should be made behind the ear and the skin removed to give a

denuded area on the ear, and a similar area adjacent to it on the scalp. The ear is then pressed back and the edges of the wounds sutured (Fig. 2095).

If replacement of the ear is prevented by the cartilage of the concha, a small elliptical piece of cartilage should be excised. In aggravated cases

Fig. 2093.

Fig. 2094.

Figs. 2093 and 2094.—Kolle's Operations for Reducing Size of Ear.
Showing lines of incision.

the elliptical resection may involve the whole thickness of the ear. The wound is then sutured anteriorly as well as behind the ear. The wounds should be dressed with gauze back of the ears holding the posterior margin or the ear about 1.25 cm. (½ inch) away from the head.

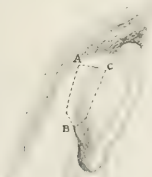


Fig. 2095.

Fig. 2096.

Fig. 2095.—Operation for Lop-ear.
Showing ear pressed forward. Denuded area, half on ear and half on scalp. Line *CB* is sutured to line *AB*.

Fig. 2096.—Operation for Relief of Attachment of the Lobe of the Ear.

Attachment of the lobe to the side of the head deprives the ear of a pendulous lobe. This may be corrected by freeing the lobe by a plastic incision and closing the two wounds on the ear and the side of the head (Fig. 2096).

Laceration of the lobe (coloboma) is commonly caused by the tearing out

of earrings. The edges of the cleft should be freshened, but skin should not be sacrificed any more than is necessary. The way not to do the operation is by the methods generally described (Figs. 2097 and 2098). The same principle should be applied here as in operations for harelip. A slight

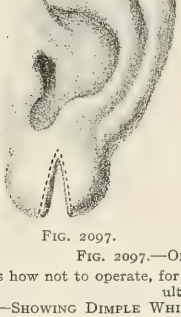


Fig. 2097.

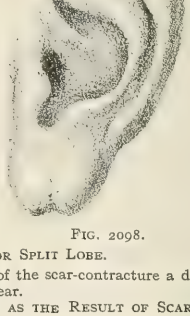


Fig. 2098.

Fig. 2097.—Operation for Split Lobe.

This shows how not to operate, for as a result of the scar-contracture a dimple will ultimately appear.

Fig. 2098.—Showing Dimple Which Appears as the Result of Scar-contracture after Simple Linear Suture of Wound of Lobe of Ear.

protuberance should be made to compensate for the scar contraction which will follow (Figs. 2099 and 2100). Any of the other expedients used for operating on harelip are applicable here. A small deformity following an

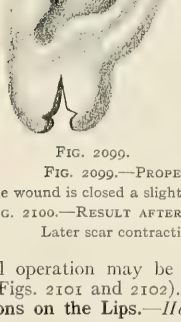


Fig. 2099.

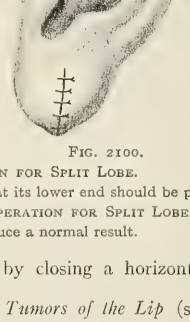


Fig. 2100.

Fig. 2099.—Proper Operation for Split Lobe.

When the wound is closed a slight projection at its lower end should be present

Fig. 2100.—Result after Proper Operation for Split Lobe.

Later scar contraction will produce a normal result.

unsuccessful operation may be corrected by closing a horizontal wound vertically (Figs. 2101 and 2102).

Operations on the Lips.—*Harelip and Tumors of the Lip* (see Vol. II, page 250).

Ectropion (eversion) *of the lower lip* is treated by the same operation as for the eyelid (Vol. II, page 144). The operation of widest utility is the

V-incision on the chin, converted in a Y-shaped line of suture. If there is redundancy of lip tissue a segment may be removed from the lip.

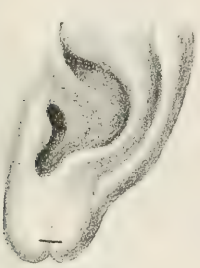


FIG. 2101.

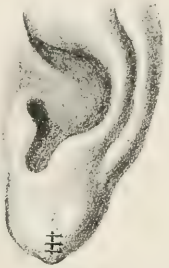


FIG. 2102.

FIG. 2101.—INCISION FOR CURE OF DIMPLE OF LOBE TO BE TREATED BY CLOSING HORIZONTAL WOUND VERTICALLY.

FIG. 2102.—RESULT AFTER VERTICAL CLOSURE OF HORIZONTAL WOUND TO REMOVE DIMPLE OF LOBE OF EAR.

Absence of lip is treated by the same plastic principles as are applied in restoring defects of the cheek. Usually it is best to swing down a flap, having its base open toward the direction from which the supplying vessels come (Figs. 2103, 2104, 2105 and 2106).

FIG. 2103.

FIG. 2104.

FIG. 2105.

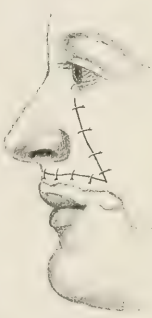


FIG. 2106.

FIGS. 2103 AND 2104.—RESTORING LOST LOWER LIP BY SWINGING DOWN FLAPS FROM ABOVE.

The flap contains the angular artery.

FIGS. 2105 AND 2106.—RESTORING LOST UPPER LIP BY FLAP FROM ABOVE.

The flap contains the angular artery.

Operations on the Mouth.—*Macrostoma* (abnormally large mouth) may be treated by removing the mucous membrane at each angle of the buccal opening and suturing the denuded surfaces together (Figs. 2107 and

2108). For less aggravated cases the simple V incision closed as a Y line of suture suffices (Figs. 2109 and 2110).

Microstoma (abnormally small mouth), whether congenital or due to cicatricial contracture, is easily amenable to treatment. If the contraction is moderate in amount and scar tissue does not prevent, an operation should be done which preserves the orbicularis oris muscle. This can be accomplished by making a transverse incision just external to the muscle and sutur-

Fig. 2107.

Fig. 2108.

Fig. 2107.—Incisions for Operation for Macrostoma.
Reducing size of mouth.
Fig. 2108.—Wounds Closed in Operation for Macrostoma.

Fig. 2109.

Fig. 2110.

Fig. 2109.—Incisions for Plastic Operation for Macrostoma.
Fig. 2110.—Incisions Sutured to Reduce Length of Mouth Opening.

Fig. 2111.

Fig. 2112.

Fig. 2111.—Incisions for Operation for Microstoma to Enlarge Size of Mouth.
Fig. 2112.—Incisions Closed to Lengthen Mouth-opening.

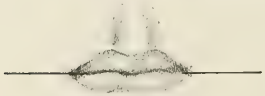


Fig. 2113.

Fig. 2114.

Fig. 2113.—Incisions for Operation for Enlarging Size of Mouth.
Fig. 2114.—Wounds Sutured after Incisions for Enlarging Size of Mouth.
The incisions pass through the whole thickness of the cheek, and the lining mucous membrane is sewed to the skin.

ing the muscle at the outer part of this wound on either side (Figs. 2111 and 2112). As a later step the mucous membrane may be everted by a plastic operation. The most simple operation consists in making lateral incisions through the thickness of the cheeks. Unfortunately these incisions divide the orbicularis oris muscle. The mucous membrane of the inside of the mouth is sewed to the skin of the cheek. A later plastic may be done to further evert the mucous membrane (Figs. 2113 and 2114; see also Operations on the Lips, Vol. II, pages 247 and 266).

Operations for Defects of the Cheeks.—All of the methods of plastic repair described above are applicable to the cheeks. The exceptions are that curved incisions are to be preferred. So far as possible incisions should follow the natural lines of the face.

For covering *defects not involving the whole thickness of the cheek*, flaps or grafts may be used. The great vascularity of the face and the elasticity of the tissues make these operations very successful (Figs. 2115, 2116 and 2117).

For *restoration of the whole thickness of the cheek*, the mucous membrane inside of the mouth can usually be freed at its edges and sutured across the gap, after which a flap may be used to cover the external defect (Figs. 2118 and 2119). When this cannot be done a flap, having epithelium on both

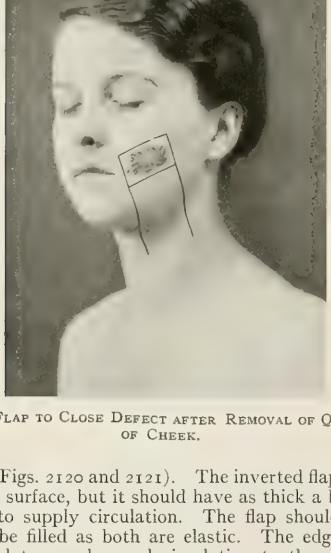


FIG. 2115.—SLIDING FLAP TO CLOSE DEFECT AFTER REMOVAL OF QUADRILATERAL AREA OF CHEEK.

sides, is necessary (Figs. 2120 and 2121). The inverted flap may be detached throughout its skin surface, but it should have as thick a base of connective tissue as possible to supply circulation. The flap should be cut the size of the opening to be filled as both are elastic. The edges of the opening should be freshened to supply good circulation to the edges. The hairy surface in men which is turned into the mouth is uncomfortable for a while but ultimately loses its hair and assumes the quality of mucous membrane. The raw surface remaining, having twice the size of the original opening, may be covered by skin-grafting or by a flap from the neck (Figs. 2122 and 2123).

To obviate the danger of defective circulation in the first flap, Israel cut a flap from the neck twice as long as is necessary, left it attached at its base and turned its free end into the opening (Figs. 2124 and 2125). The flap is sutured into the defect and left with its raw surface exposed until it

FIG. 2116.—SLIDING FLAP CLOSING DEFECT OF CHEEK.

FIG. 2117.—SLIDING FLAPS TO RESTORE LOWER LIP.

has developed a circulation through its sutured border. This requires from fourteen to eighteen days. The granulations are then shaved off of the raw surface, the pedicle divided at its base and doubled upon itself over the defect. During the two weeks it will be found that the pedicle has shrunken

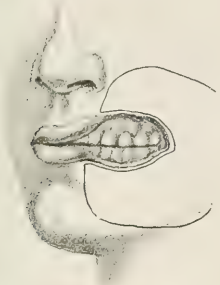


Fig. 2118.

Fig. 2119.

Figs. 2118 and 2119.—Restoration of Cheek for Defect at Angle of Mouth.

considerably; but by under-cutting the skin around the defect or performing an additional plastic the wound may be closed (Fig. 2126).

The skin of the forehead is preferred by Bardenheuer for closing buccal defects. It has no hair, its circulation is good, and the forehead defect is

Fig. 2120.

Fig. 2121.

Fig. 2120.—Closure of Defect Involving Thickness of Cheek.

The skin surface is turned into the mouth to become continuous with the mucous membrane. The flap should have enough tissue left at its base to guarantee nourishment.

Fig. 2121.—Skin Flap from Neck to Cover Denuded Area of Face.

easily covered by grafts. The angular artery, the termination of the facial, furnishes abundant nourishment if the pedicle is left between the base of the nose and the eye. The forehead flap is firm, contracts but little, and has

little fat. The outer flap to cover the inverted flap may be taken from the neck.

Fig. 2122.

Fig. 2123.

Fig. 2122.—Wound Area of Face, to Involve Whole Thickness of Cheek, to be Covered by Flap Which is to Provide Epithelial Lining for Buccal Surface.

Fig. 2123.—Area of Cheek to be Covered by Flap from Front and Side of Neck after Skin Flap has been Turned in with Skin Surface in Buccal Cavity.

Transplantation of *flap with the temporal artery*, worked out by Dunham, Horsley and Esser (Annals of Surg., March, 1917, page 297) is indicated for

Fig. 2124.

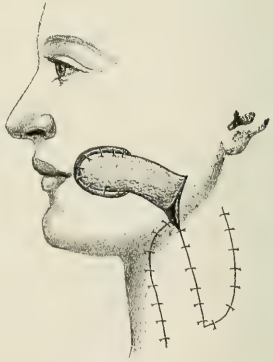


Fig. 2125.

Fig. 2124.—Closure of Defect of Cheek by Flap from Neck.

Showing provision for sliding flaps to cover denuded area after central flap is turned up. The mucous membrane in this case may be dissected free and sewed across the gap and the inverting of a flap obviated.

Fig. 2125.—Flap Inverted and Skin Surface Sewed to Mucous Membrane.

The defect from which the flap is taken is closed by two lateral sliding flaps.

closing large defects of the cheek in which deficient vitality of the flap means serious failure. The epithelial lining for the cheek may be secured by a flap from the neck. This is inverted and sewed in place in the opening with its

skin side in the mouth. If the mucous lining is made by sliding the mucous membrane from the cheek and side of the tongue, no preliminary skin flap is necessary.

FIG. 2126.—PEDUNCULATED FLAP CUT AND FOLDED UPON ITSELF.
This flap has formed an epithelial lining for the cheek and a skin covering. The scar of the plastic in the neck still shows.

FIG. 2127.—METHOD OF DISSECTING OUT TEMPORAL VESSELS WITH FLAP.
The mucous membrane lining the cheek has been freed and sewed across the defect. The temporal flap is to be transplanted with its vessels still attached. Such a flap as this may be used to supply an epithelial lining for the mouth.

The essential step in the operation is dissecting out the temporal artery and vein. The flap to cover the defect is marked out on the forehead. An incision is then made in the line of the artery from its beginning to the

point where it enters the flap. The artery is then dissected free together with some connective tissue lying beside it containing the veins. It should not be touched with forceps. Only the connective tissue should be grasped. The

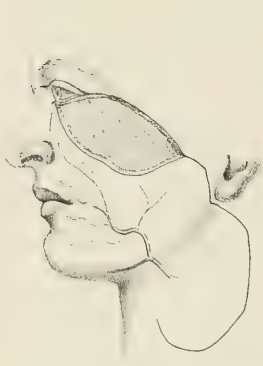


FIG. 2128.

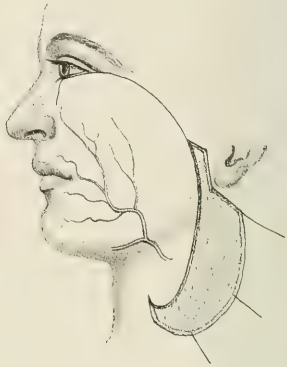


FIG. 2129.

FIG. 2128.—OPERATION FOR DEFECT OF CHEEK WITH ESPECIAL REFERENCE TO THE FACIAL ARTERY.

FIG. 2129.—SLIDING FLAP MOVED UP TO COVER DEFECT OF CHEEK. The secondary wound is closed by undercutting and suturing.

flap with the artery running into it is then cut free. A straight incision is made from the artery to the defect in the cheek and the wound undermined slightly on either side. This should not be so deep as to injure the facial

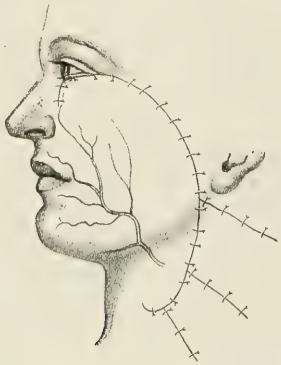


FIG. 2130.—WOUNDS CLOSED AFTER COVERING DEFECT WITH SLIDING FLAP.

nerve. The artery is laid in this wound. The flap is sewed in place and all of the wounds closed (Fig. 2127).

The use of *sliding flaps with the facial artery* is effective. For the loss of tissues of the cheek such a flap may be slid up, using some of the skin of the neck with the subcutaneous fascia. The incision should be made in such

FIG. 2131.—OPERATION FOR DEFECT OF UPPER LIP WITH ESPECIAL REFERENCE TO PLACING THE FACIAL ARTERY IN THE FLAP.

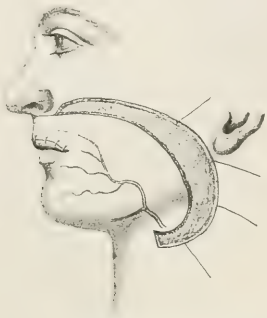


FIG. 2132.—SLIDING FLAP WITH FACIAL ARTERY IN DEFECT OF UPPER LIP.

a way that the zone of the artery is embraced in the flap (Figs. 2128, 2129 and 2130). For loss of the lip the same principle is employed, a cheek-neck

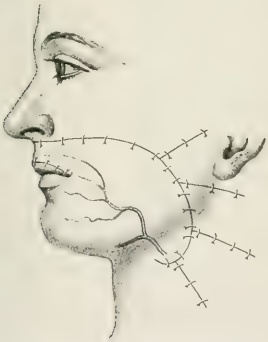


FIG. 2133.—WOUNDS CLOSED AFTER SLIDING FLAP WITH FACIAL ARTERY HAS BEEN PLACED IN DEFECT OF UPPER LIP.

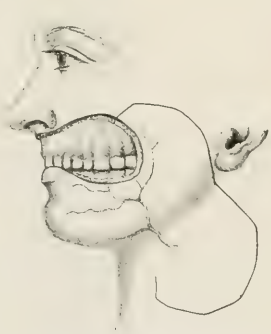
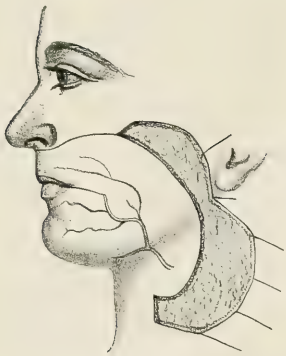


FIG. 2134.—OPERATION FOR DEFECT OF CHEEK AND UPPER LIP WITH ESPECIAL REFERENCE TO PLACING THE FACIAL ARTERY IN THE FLAP.

flap is mobilized and slid forward (Figs. 2131, 2132 and 2133). For loss of lip and cheek tissue, a similar operation is done (Figs. 2134, 2135 and 2136). In any operation of this sort, it is important that the vessels of the part should



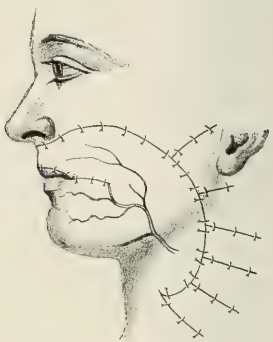


Fig. 2135. Fig. 2136.

Fig. 2135.—Sliding Flap Moved into Defect of Upper Lip.
Fig. 2136.—Wounds Closed after Placing Flap in Defect of Upper Lip.

Fig. 2137.—Operation for Defect of Mucous Membrane of Cheek.

This operation is done when cancer of the mucous membrane does not extend to the skin. The incision 1-2-3 is made, the flap turned up, and the tumor removed as shown by the dotted line. The skin flap *A* is thencut and left attached at its base above. It is turned in and sewed in the mucous-membrane defect to provide any epithelial lining. The points *a* and *b* of the skin flaps *aef* and *beg* are to be carried upward to the line 1-2-3 and sewed.

enter the flap. That means that the base of the flap or the pedicle should be toward the supply vessels. J. F. Esser worked out a series of these plastics for preserving the nourishment supplied to the flaps by the facial artery.

In cases of *defect of the mucous membrane* only on the inner side of the cheek, such as follows operation for the removal of epithelioma which does not extend through to the skin, G. G. Davis (Surg., Gyn. and Obst., xxi, 1915) laid open the mouth by turning up a cheek-flap, and turned into the mucous membrane defect a skin-flap from the neck. The defect in the neck is covered by sliding flaps (Figs. 2137 and 2138).

A *double transplanted flap* may be taken from the forearm or upper arm to fill a defect of the cheek. The flap is made quadrilateral in form, is left

FIG. 2138.—WOUND CLOSURE AFTER OPERATION FOR DEFECT OF MUCOUS MEMBRANE OF CHEEK.

The mucous membrane has been removed, the flap *A* sewed in the defect in the inner surface of the cheek, the points *a* and *b* brought up to the line 1-2-3, and the folds at *c* and *d* closed.

attached at one end, and doubled upon itself (Fig. 2139). The forearm furnishes a flap which is too thin excepting in fat people. For this reason the flap is best taken from the front of the upper arm. It is dissected up, folded double and the edges sewed together. The denuded surface is covered at once with skin-grafts. One or two weeks later, the defect in the cheek is freshened, the graft-flap is trimmed to fit it, and it is sewed in place by sutures inside and outside. The patient's arm is held to the head by a plaster-of-Paris bandage, which should include the chest. The patient must be made comfortable. Only sterile food should be given, and this should be placed in the esophagus by a stomach tube. The cleansing of the mouth should be vigorous. In about ten days or two weeks the flap should be found to have united to the cheek and it may be cut free from the arm. Later cosmetic operations may be required.

Operations on the Nose (Rhinoplasty).—*Operations for reconstruction of the nose* (complete rhinoplasty) are required after loss of that appendage from wounds, syphilis, tuberculosis, lupus, neoplasms, gangrene from freezing, burns and operations. A nose that has recently been cut off may be replaced and sutured and a successful result expected if not too long a time has elapsed and if fair asepsis has been secured. The circulation in the tissues of the face is so vigorous that some remarkable results have been obtained long before the aseptic era.

Restoration of the totally destroyed nose will first be discussed. When the destruction has been due to syphilis or other infective disease operation should not be attempted until the disease has been cured. When due to local disease it is important that the disease should first be eradicated. Excessive

FIG. 2139.—DOUBLE FLAP TO CLOSE DEFECT OF CHEEK.
By fixing the arm to the head, as a secondary operation, this double flap may be sewed into a defect of the cheek and an epithelial covering for both sides secured.

scar tissue about the base of the nose, shutting off the blood supply should also be eliminated before operation is done. Before beginning an operation the surgeon should have a perfectly thought out plan of procedure so that the operation once begun moves on to its end with despatch.

The *local preparation* for such plastic operations should receive especial attention. The vestibule should be prepared by cutting away the hairs. The nasal cavities should be washed out with warm salt solution. The vestibule should then be washed out with soap and warm water applied with soft gauze, and cleansed with boric acid solution. The face should be washed with soap and water. Tincture of iodin completes the sterilization of the field.

The *anesthetic* for operations on the nose should be administered by rubber tubes through the mouth, rectal anesthesia or local anesthesia. A posterior

nasal tampon should be inserted to prevent blood flowing into the pharynx, if a general anesthetic is used.

Beard and mustache should be shaved. The operation should be done with every attention to asepsis. Rubber tubes should be placed in the nares to preserve the shape. The primary dressing should be changed with the greatest care lest the lines of union be disturbed. If the dressing can be left for a week or more so much the better.

Many operations are required before the surgeon and patient can be satisfied. There remains often room for improvement even after the most successful of these operations.

Rhinoplasty by soft flaps, having no solid substance for support, is scarcely worth the pains, as the nose flattens and soon becomes misshaped. Such

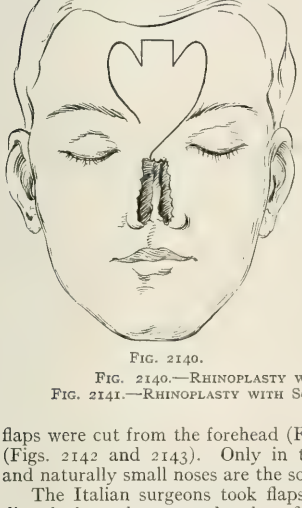


FIG. 2140.

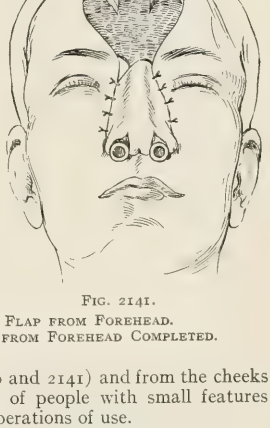


FIG. 2141.

FIG. 2140.—RHINOPLASTY WITH SOFT FLAP FROM FOREHEAD.
FIG. 2141.—RHINOPLASTY WITH SOFT FLAP FROM FOREHEAD COMPLETED.

flaps were cut from the forehead (Figs. 2140 and 2141) and from the cheeks (Figs. 2142 and 2143). Only in the cases of people with small features and naturally small noses are the soft flap operations of use.

The Italian surgeons took flaps from remote parts, transplanting them directly from the arm or hand, or first attached a flap from the trunk to the forearm and then transplanted it on the nose. In these operations the hand is made fast to the head or other parts by means of plaster-of-Paris casing.

Prosthetic supports for the soft flaps have been used with little success.

Double skin flaps, or lined flaps, were employed with better success; but these operations also result ultimately in flattening the nose. The lining of the nasal bridge with epithelium does much to insure the permanence of the result (Figs. 2144 and 2145). Flaps may be taken either from the forehead or the face (Figs. 2146 and 2147) or they may be transplanted from remote parts.

Soft-flap rhinoplasty with septum reconstruction gives somewhat better success. A forehead flap, divided in the median line, is turned down and

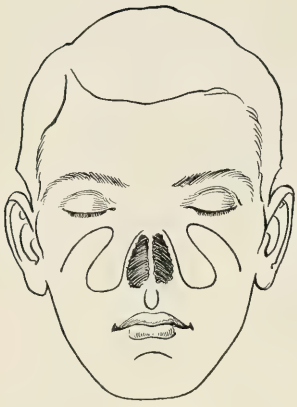


FIG. 2142.

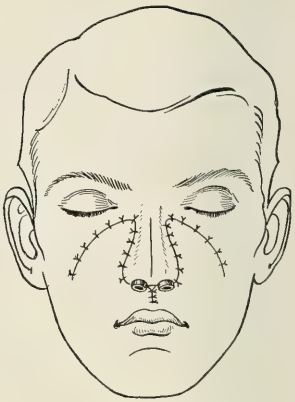


FIG. 2143.

FIGS. 2142 AND 2143.—RHINOPLASTY WITH SOFT FLAPS FROM CHEEKS AND LIP. The lip flap is turned up and rotated to form the front of the septum. Rubber tubes are placed in the reconstructed nostrils.

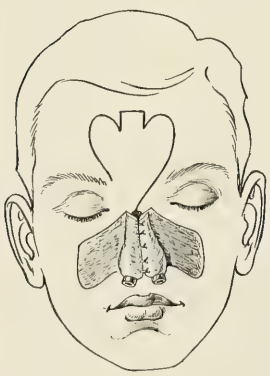


FIG. 2144.

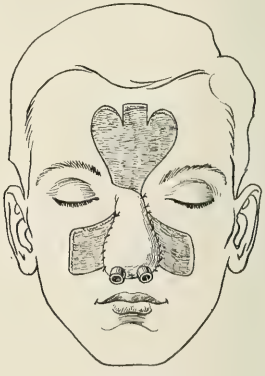


FIG. 2145.

FIG. 2144.—DOUBLE SOFT-FLAP RHINOPLASTY. Cheek flaps have been sewed across nose.

FIG. 2145.—FOREHEAD FLAP TURNED DOWN IN DOUBLE-FLAP RHINOPLASTY.

sewed together, raw surface to raw surface, and this double flap is sewed to the remains of the septum. Upon this new septum flaps from the cheeks, or from some other part are placed as a covering.

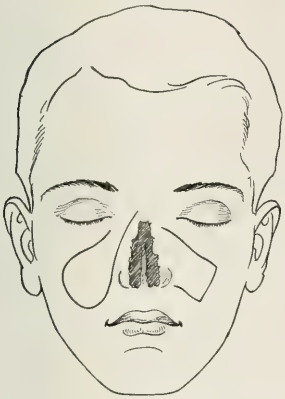


Fig. 2146.

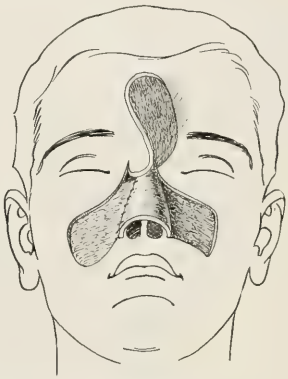


Fig. 2147.

Figs. 2146 and 2147.—Double-Flap Rhinoplasty with Flaps from the Face.

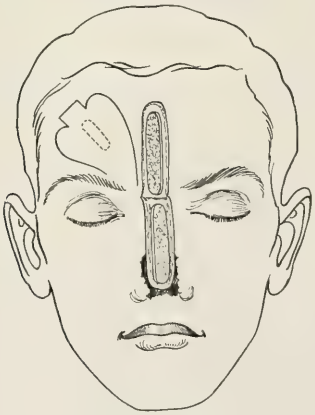


Fig. 2148.—Osteoplastic Rhinoplasty.

A flap of bone and scalp is turned down from the middle of the forehead and sewed in place. A flap with a bone plate is taken from the forehead laterally.

Bony and cartilaginous supports for rhinoplastic flaps have made these operations well worth while. Without them but poor successes were secured.

The organic material for giving firmness and permanence to the reconstructed nose may be taken from any available location. Bone is taken from the forehead, tibia, sternum, radius, or from amputated parts. Cartilage is taken from the costal cartilages, or amputated ears. A solid result may be secured by using a transplanted toe.

The operation, as devised and practiced by F. König takes a skin-bone flap from the median line of the forehead, about 1 cm. (⅓ inch) wide. This flap is first cut as far as the bone, then with a chisel the outer layer of the skull is cut through. The flap is freed, turned down, and sutured, with the raw bone surface forward, at the junction of the upper lip and the septum. The skin edge around the nasal opening is then cut free and this inner skin edge, so far as possible, is sewed to the skin edge of this flap. The covering flap is then cut from the forehead at the side of the first flap. This is rotated and

Fig. 2149.

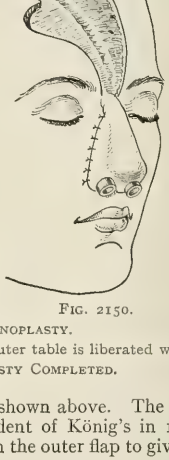


Fig. 2150.

Fig. 2149.—Osteoplastic Rhinoplasty.

The flap is stitched together while a strip of the outer table is liberated with it.

Fig. 2150.—Osteoplastic Rhinoplasty Completed.

turned down as in the old soft flap-operations shown above. The forehead defects are covered by skin grafts. As a student of König's in 1891 and 1892, I have seen him leave a strip of bone also in the outer flap to give further support and contour to the nose (Fig. 2148).

Other surgeons omitted the first flap of König and relied entirely upon the bone which could be included in the covering flap. There are many modifications of this operation. A flap of adequate size is cut from the forehead, its base lying between the root of the nose and the eye, to receive the angular artery. This flap is dissected free on either side, leaving an attachment to the bone about 1 cm. wide throughout its whole length. The sides of the flap are temporarily sewed together, and this strip of bone, representing the outer table of the skull is chiseled free (Fig. 2149). Its attachment to the flap is carefully preserved. Bone is not left in the pedicle. The edges of the nasal

opening are then freshened and the flap is rotated and sewed in place. The free end is bent down to form the front of the septum (Fig. 2150).

The most important modification of the above operation consists in cutting a flap having a bone plate about 3.5 cm. (1⅓ inches) wide. The flap should be about 5 cm. (2 inches) wide. The bone plate should be about 4 cm. (1½ inches) long. It should not involve the pedicle of the flap. It is chiseled from the outer table of the skull, and its attachment to the flap should be carefully preserved from injury. This flap is turned down without being rotated, and its raw, bony and connective-tissue surface is allowed to become covered with granulations. When this has occurred the bone is divided longitudinally into three pieces with a fine saw. The middle section should be about 8 mm. (5/16 inch) wide. The sides are bent down and sewed to the freshened margin of the nasal opening. This raw surface is then covered by a flap from the arm or by lateral flaps from the face. The margin of the nasal opening may be cut free and turned down to form the edges of the nostrils. A front septum may be made by a flap from the upper lip. This last operation may be done in one stage; the flap may be rotated; or other advantageous modifications may be made. The operation is best done by first turning in a lining flap from the cheek, and then rotating the forehead flap with the skin forward.

In any of the above operations in which epithelial lining is not provided for the new nasal tissue it may be secured by turning in a flap from cheek as a preliminary step. This is shown in the following operation. The cheek flap, with its epithelium downward, is sewed in place. The bony flap from the forehead is then rotated over it. This flap may contain the broad bridge of bone, to be divided into three sections, or it may contain one long median strip.

Cartilaginous support was employed effectively by C. Nélaton. He inserted a flat piece of cartilage, taken from the costal cartilage, under the periosteum of the forehead; and at a later operation turned down the flap containing this cartilage. This operation may be done as follows: The outline of the nasal flap is marked with pencil on the forehead and a paper pattern cut of the same shape. The flap may be made horizontally to minimize the amount of rotation required. A vertical incision 1 cm. (⅓ inch) long, is made in the proposed middle of the apex of the flap. This incision should go down to the bone. A thin sharp periosteal elevator is passed in and the periosteum lifted up tunnel-fashion for a distance of about 5 cm. (2 inches) (Fig. 2151). An incision should then be made along the front of the costal margin. It should begin about 2.5 cm. (1 inch) from the costoxiphoid junction, pass downward and outward until it reaches the cartilage of the eighth rib which it should follow as far as the costochondral junction. The muscles attached to this eighth costal cartilage should be reflected downward, and the cartilage exposed. A section of the cartilage about 5 cm. (2 inches) long should be resected. This should be cut so that it is straight and has one end rounded or pointed. The cartilage is pushed into the tunnel on the forehead and the skin wound closed over it with a couple of sutures. The cartilage should be left here for two or three months.

When the cartilage has had sufficient time to become well fixed, the second stage of the operation is undertaken. An incision is made around the border of the nasal opening far enough to give skin to turn in as a lining flap. The apex is turned down and the side flaps are sewed to it. If there is not enough skin for this a flap may be turned in from the cheek or a flap transferred from the arm. It is often wise to defer turning down the frontal flap till granulations have sprung up on the raw side of the lining flap.

The forehead flap is cut according to the pattern (Fig. 2152). The incision which marks it out should include periosteum. With a sharp elevator the periosteum is raised with the flap. This carries with it the implanted cartilage. The flap is swung around upon its pedicle and fitted in place. The cartilage should lie along the length of the nose. At the end a wedge-shaped notch should be cut in the cartilage and the end broken and bent downward to form the front of the septum. The free edge of skin should be turned back and sewed to make a lining for the wings of the nostrils. The nose is then sewed in place. Rubber tubes are placed in the nares to keep them open (Fig. 2153). The forehead wound is covered with grafts or a transplanted skin flap.

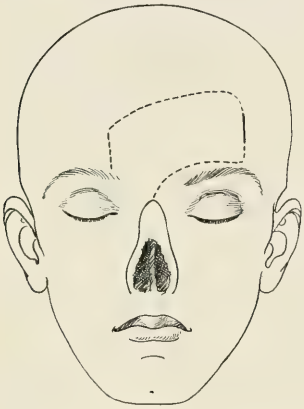


FIG. 2151.

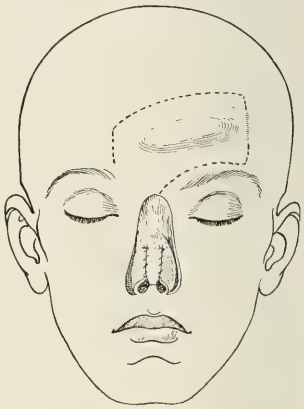


FIG. 2152.

FIG. 2151.—RHINOPLASTY WITH CARTILAGINOUS SUPPORT.

The location of the forehead flap is shown by dotted line. Heavy line on forehead shows incision for inserting cartilage under scalp. Incision about nose is for turning in skin to line nasal cavities.

FIG. 2152.—RHINOPLASTY WITH CARTILAGINOUS SUPPORT.

Costal cartilage has been inserted under scalp of forehead and wound healed. Skin around border of nasal opening has been turned in and sewed.

The *transfer of bone and cartilage from distant parts* has met with decided success. This is best done by means of the arm. A lining flap first should be applied. This may be taken from the margin of the nose, the cheek, forehead, or arm. After its vitality is assured by the appearance of granulations, the outer covering is provided. Israel took a bone-flap from the forearm and incorporated a piece of the ulna. The radius may be used. A flap, similar in shape to the forehead flaps, is cut from the radial side of the left forearm (Fig. 2154). This flap should be so placed that the bone is taken from the lower part of the outer side of the radius just above the styloid process. The pedicle runs onto the wrist. The bone should be about 5 cm. (2 inches) long and 8 mm. ($\frac{5}{16}$ inch) wide. The anterior incision should be made first and the radial nerve retracted forward out of the way of harm.

The bone should be cut with a sharp chisel. It can be cut with a saw Care should be taken not to disconnect the attachment of the flap to the bone.

The closed fist is placed with its radial side against the forehead, and the flap sewed in place around the edges of the nasal opening (Fig. 2155). The flap and the wound are dressed and the arm, hand, and head are fixed in plaster-of-Paris so that motion at the flap is impossible. The flap is cut free from the arm after two weeks, and the end and wings of the nose shaped. The bone should be fractured in the flap and the front end bent down to form the front of the septum.

Cartilage from the costal arch may be transferred by using the forearm as a vehicle. A flap containing cartilage, is cut from the region of the costal arch. This flap is made broad enough so that when the cartilage is cut the skin may be wrapped around it. It is taken from the eighth costal cartilage, as described above in the operation of Nélaton, but is left attached to the skin.

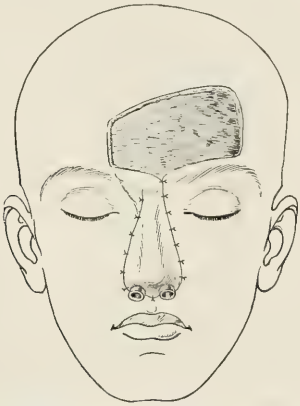


FIG. 2153.—RHINOPLASTY WITH CARTILAGINOUS SUPPORT.
Forehead flap containing cartilage is turned down and sewed in place. Rubber tubes are placed in nostrils to preserve their patency.

The skin is cut in such a way that a bridge is made, and after the cartilage is freed the skin is wrapped around the free segment (Figs. 2156 and 2157). This can best be done in the case of a lean person. A bridge of skin is left enveloping a segment of cartilage. This is left for a month or two, then a transverse elliptical wound is made on the front of the forearm near the wrist. The lower end of the bridge is cut free, and sewed in this wound. The hand and arm are made fast to the body while the flap is uniting to the forearm. This requires about two weeks. At the end of that time the upper end of the bridge is cut from the chest wall.

The flap attached to the forearm, is then transferred to the nose. It is trimmed to the desired shape. The edge of the nasal cavity is freshened. Incisions are made through the skin of the flap in the shape of the nasal cavity and the skin is reflected back for a short distance. Fresh incision in the flap is then sewed to the freshened edge of the nasal opening. The palm of the hand is laid on top of the head as the operation is completed. The

hand, arm, and head are fastened together with plaster-of-Paris and held in this position for two weeks while the flap is growing fast to the nose. The flap is then cut free from the forearm and the modeling of the nose completed.

Transplanting of distant structures has unlimited possibilities. This same principle may be used in carrying bone and cartilage flaps from remote parts of the body. Using the forearm or hand as a vehicle, bone may thus be taken from the crest of the tibia, from the ribs or the sternum. The bone or cartilage to be transplanted may first be enveloped in skin, as shown above, or it may be transferred lying on the free raw surface. It does best when first enveloped in a skin covering. A toe may be grafted upon the hand and thence successfully transferred to the nose.

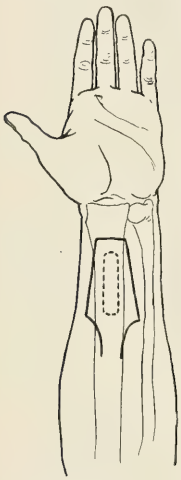


FIG. 2154.—FLAP FROM FOREARM CONTAINING BONE.

If a patient cares to sacrifice the *little finger* of the left hand, it lends itself admirably to nose reconstruction. Depending upon the size of the face one or two phalanges may be used. The proximal and distal phalanges are best adapted to most cases. The bone should not be cut through but disarticulated. If the two phalanges are used the distal phalanx may be employed to form the forward part of the septum. The nail should be cut out and its matrix destroyed. The skin along the radial side of the distal phalanx should be incised longitudinally down to the bone. This incision should be continued up to the head of the proximal phalanx. The whole bone of the middle phalanx is exposed and removed, being disarticulated at the two phalangeal joints.

The skin is traumatized as little as possible. A longitudinal wound is then made on the palm of the little finger opposite the proximal phalanx. The skin edges of this palmar wound are dissected back a short distance. The extensor and flexor tendons should be drawn down and cut as short as possible. The distal phalanx then is folded upward and sewed by the skin edges of the wound on its outer side to the palmar wound opposite the upper phalanx. Thus the last phalanx of the finger is rotated a quarter of a circle and sewed edgewise to the front of the proximal phalanx. Before making this connection the lateral skin incision may be connected to the palmar incision and the two wounds spread wide enough to permit sewing the skin on either side (Fig. 2158). In most cases a better union will be secured by cutting out a strip of skin from the radial side of the distal phalanx. The palmar wound in front of the proximal phalanx must spread apart to conform to this. If the proximal phalanx is going to be too large, a strip of skin also may be removed to make a broader wound. All of this depends upon the character of the tissues and the size of the structure.

The end phalanx is to serve as nasal septum and the proximal phalanx is destined to form the body of the nose. If the little finger is too small the ring finger or middle finger may be used instead. If this is done, when the finger is disarticulated the head of the metacarpal bone should be removed to permit better closure of the space from which the finger was removed.

In two or three weeks, after good union has been secured, the end of the stump is cut and shaped in such a way as to fit the upper part of the nasal

FIG. 2155.—OSTEOPLASTIC FLAP FROM FOREARM FIXED TO NOSE

FIG. 2156.—COVERING SEGMENT OF COSTAL CARTILAGE WITH A WRAPPING OF SKIN. Showing skin incisions. The cartilage is cut free but is not detached from the skin.

defect. When ready for transplantation an incision is made in the palmar aspect of the folded-over stump, and the skin dissected back to make a wound which shall be coapted to the remains of the nasal septum. The edge of the septum should be freshened to unite with this wound (Fig. 2159). A

FIG. 2157.—SEGMENT OF CARTILAGE COVERED WITH WRAPPING OF SKIN.

flap is turned back to unite with the denuded skin at the apex of the nasal opening An incision, continued on the outer and inner sides of the finger, curves around opposite the metacarpophalangeal joint, and makes a wound which is to be united to the freshened border of the nasal opening. The skin

FIG. 2158.

FIG. 2159.

FIG. 2158.—RHINOPLASTIC TRANSPLANTATION OF FINGER. (J. P. W.)

The finger nail and matrix have been removed from little finger. The middle phalanx is removed. The end phalanx is rotated 90° and sewed to the palmar aspect in front of proximal phalanx.

FIG. 2159.—RHINOPLASTIC TRANSPLANTATION OF FINGER. (J. P. W.)

The end phalanx has been attached to the palmar surface of the proximal phalanx. Dotted lines show incisions for next step.

is dissected back far enough to allow suturing. The flexor tendon is drawn down and divided as short as possible.

The hand is then carried to the face and the finger sutured to the nose as above indicated. The hand, arm, and head are fixed in plaster-of-Paris dressing. After about two weeks, when union has been secured a flap is marked out on the dorsum of the hand which shall furnish material to make

the wings of the nostrils and cover the anterior edge of the septum and tip of the new nose (Fig. 2160). The finger is disarticulated at the metacarpophalangeal joint. The remains of the extensor tendon is removed, and the end of the nose is shaped.

Operations such as this are best done under local anesthesia. General anesthesia sacrifices the intelligent coöperation of the patient which is highly valuable in so delicate an operation.

Foreign-body support has been used with some success, but has now been quite supplanted by substances which are capable of becoming organized. In 1897 (Brooklyn Medical Jour., Feb., 1898) I had made for a man with saddle-nose, a gutta-percha bridge, perforated with holes, which I slid under the skin of the nose. This was all done through an incision at the end of the

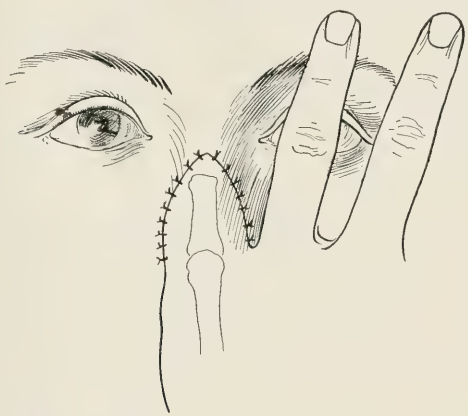


FIG. 2160.—RHINOPLASTIC TRANSPLANTATION OF FINGER. (J. P. W.)

The prepared finger is sewed to the nose, and the hand held to the face by adhesive plaster and plaster-of-Paris dressing. The later amputation of the finger should provide skin enough to shape the nostril openings.

nose, carried along the borders of the alæ and the tip of the nose. With scissors and a narrow knife the skin was dissected free as far as the nasofrontal juncture. After inserting the rubber form, the wound was closed with a subcuticular suture. It healed perfectly; and when last heard of five years later was in place and had caused no disturbance (see Saddle-nose).

In operations for slipping a foreign body, bone or cartilage under the skin of the nose, the opening may preferably be made at the tip of the nose, but if this seems too difficult it may be made at the root of the nose between the eyes. A vertical incision thus placed allows the entrance of a pair of fine scissors, and with these the skin may be undercut as far as the tip of the nose.

Operations for partial defects of the nose (partial rhinoplasty) are carried out on the same principles as for total restoration as above described. Smaller flaps may be used. In many cases enough tissue is present to correct the defect by sliding down a flap from above (Figs. 2161 and 2162). Ollier

included the nasal bone in this flap and used it to give support to the nose. The cartilaginous or bony parts from the margin of the opening may be embraced in such sliding flaps. Nélaton included a strip of frontal bone in

Fig. 2161.

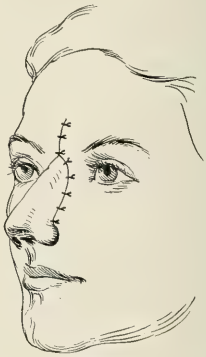


Fig. 2162.

Fig. 2161.—Rhinoplasty for Moving Nose Downward.
The flap is cut free above but left attached below.

Fig. 2162.—Rhinoplasty for Moving Nose Downward.
The flap of soft tissue and nose is moved downward, sewed in place and the wound above closed.

Fig. 2163.—Partial Rhinoplasty by Osteoplastic Flap.
Nasal processes of superior maxillary bone preserved in flap by sawing. A piece of outer table of skull is taken with the flap.

the flap. He also sawed the margins of the opening so as to leave nasal bones and part of the nasal process of the upper jaw attached to the flap (Fig. 2163).

The method of Bayer for reconstructing the alæ takes a long flap from either side of the mouth, following the natural curve of the cheeks, and reconstructs a lining for the wings and septum (Figs. 2164 and 2165). After

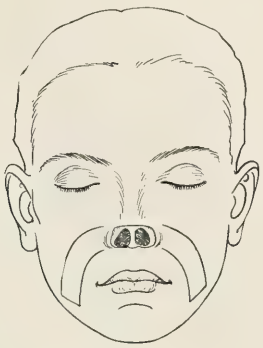


FIG. 2164.—PLASTIC OPERATION FOR RESTORING END OF NOSE.

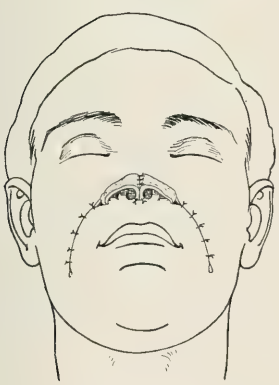


FIG. 2165.

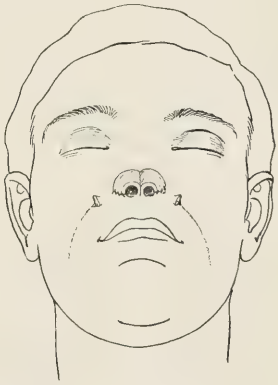


FIG. 2166.

FIG. 2165.—OPERATION FOR RESTORING END OF NOSE.

The flaps are taken from the lower part of the face on either side. New nostrils are constructed. The cheek wounds are closed.

FIG. 2166.—OPERATION FOR RESTORING END OF NOSE.

At a later operation the flaps are cut free at their bases and the surface covered with skin grafts.

two weeks when union is secure the pedicle is divided, and sutured in place (Fig. 2166). Skin-grafts are then applied, or a flap from the front of the wrist is sutured over the raw surface by fixing the palm to the forehead and immobilizing the arm and head with plaster-of-Paris. This flap when cut

free is sutured around the anterior margin of the nostrils (Fig. 2167). The result after this operation is a thick edematous nose. As circulation becomes established the edema subsides. The lack of support may be provided later by incising the anterior edges of the septum, alæ and dorsum, at different times, and sliding in between the skin layers a thin plate of cartilage taken from the rib, or elsewhere.

For *restoring small defects of the nasal wings*, sliding flaps may be used. It is well to provide epithelial lining to the nostril when the defect involves the whole thickness of the wing (Figs. 2168, 2169, 2170 and 2171). Instead of swinging in the outer flap a skin-graft may be applied. Many other means for accomplishing the same result are available. A flap of mucous membrane may be taken from the septum for lining the new outer flap.

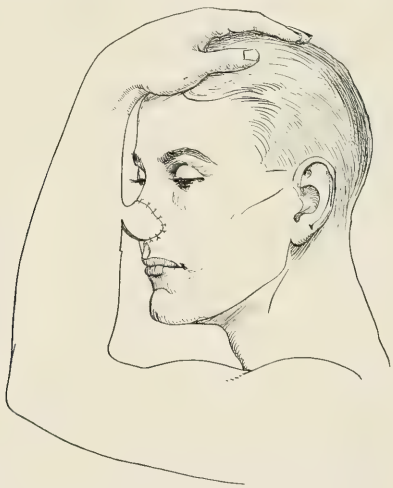


FIG. 2167.—RHINOPLASTIC FLAP TAKEN FROM FOREARM.

The whole thickness of the nasal wall above the defect may be slid down into the opening, and a plastic closure of the upper opening made (Figs. 2172, 2173 and 2174); or a lining flap may be taken from the upper lip, and a covering flap from the side of the nose (Figs. 2175 and 2176).

When soft skin-flaps are used to reconstruct the end of the nose, as a final step of the operations a dissection between the outer and inner surfaces may be made through a marginal incision, and a flat piece of cartilage slipped in to give support.

For *restoration of the septum*, a flap may be turned up from the upper lip. This reconstructed septum may later have added to it a plate of cartilage or bone slid into an opening dissected between its two surfaces.

For *correcting lateral deflection* of the whole nose, it is necessary to divide the nasal processes of the superior maxillary bones. This division should be made through an incision about 0.3 cm. (⅛ inch) long placed vertically

at the base of the process. Through this a sharp, thin chisel about 0.5 cm. ($\frac{3}{16}$ inch) is passed and with a few taps of a mallet the nasal process is divided. The operation is done on each side. By passing a large rounded

FIG. 2168. FIG. 2169. FIG. 2170. FIG. 2171.

FIGS. 2168, 2169, 2170 AND 2171.—OPERATION FOR SMALL DEFECT OF NASAL WING.

The flap *A* furnishes the epithelial lining for the nose. The flap *B* supplies skin covering for the outer side of *A*. If the remaining wounds can not be closed, skin grafts may be used.

instrument, such as forceps or a urethral sound into the nostril the nose may be pressed over into position.

If the deflection is so great that it involves also the nasal bones, these bones may be broken loose from the frontal by strong pressure or by the

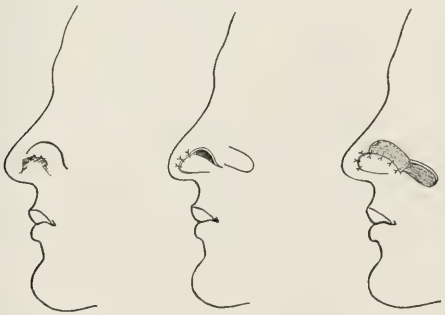


FIG. 2172. FIG. 2173. FIG. 2174.

FIGS. 2172, 2173 AND 2174.—DEFECT OF NASAL WING CLOSED BY SLIDING FLAP OF WHOLE THICKNESS OF NASAL WALL.

The flap consisting of the whole alar thickness, is slid downward into the defect. The second flap is turned over into the resulting opening. The remaining raw surfaces are to be covered by skin grafts.

stroke of a mallet applied through a pad of gauze. If the septum requires attention, which it rarely does, it may be operated upon at the same time (see Deflections of Septum, Vol. II, page 188; also Nasal Deflections, Vol II, page 192).

Operations for saddle-nose may be carried on upon the same principles as given above for nasal reconstruction. A most satisfactory operation consists in turning back two quadrilateral flaps from the saddle region, dissecting the cartilaginous part of the nose free from the bony margin above but leaving it attached below, rotating the dorsum of the fore-nose downward, turning down from the forehead a flap containing a plate of bone, and sewing the lateral flaps back over it (Figs. 2177 and 2178). A more simple operation consists in dissecting up a flap over the saddle, without opening the mucous membrane, and laying in the concavity a piece of spongy tissue from the margin of the hand or foot, or a piece of adipose tissue and then sewing back the flap in place.

A satisfactory bone transplantation may be done with a piece of rib as practised by W. W. Carter, to provide a firm subcutaneous support. A transverse incision is made across the root of the nose at the nasofrontal

Fig. 2175. Fig. 2176.

Figs. 2175 and 2176.—Defect of Nasal Wing Closed by Double Flaps. The nose-lining flap is taken from the upper lip. The skin-covering flap is taken from the side of the nose.

suture. Through this the skin is dissected up with a narrow two-edged knife, curved on the flat. This subcutaneous dissection is carried throughout the whole saddle area. Above the incision the periosteum is elevated for a distance of 1.3 cm. (½ inch). The wound is then covered, and an incision 6 cm. (2½ inches) long made over the 8th, 9th or 10th ribs at its middle. A section of the rib 4 or 5 cm. (1½ or 2 inches) long is removed from the periosteum. This bone is split lengthwise in such a manner as to give a piece of the desired shape. The medulla is scraped out. The ends are beveled, and the bone is slipped into the nasal wound. The upper end goes under the periosteum. The wounds are sutured (see also Saddle-nose, under Diseases of the Nose, Vol. II, page 192).

Operations for restoring lower jaw become necessary in cases of defective development of the jaw or deformity following injury or disease. Cases of defective development of the jaw due to ankylosis of the temporomaxillary joint may be treated and joint function restored by resection of the joint and interposing a strip of temporal fascia. At a later operation the soft tissues covering the lower jaw about the chin may be undermined, and a piece

of rib bent to fit the contour of the jaw, and inserted to give additional size to the jaw (see Operations on the Jaws, Vol. II, page 280).

Enlargement of the lower jaw may be accomplished by dividing the jaw and inserting a segment of rib in the opening thus secured.

Minor Cosmetic Operations on the Nose.—*Humped-nose*, due to undue prominence of the cartilage and bone of the crest of the nose, is treated by the

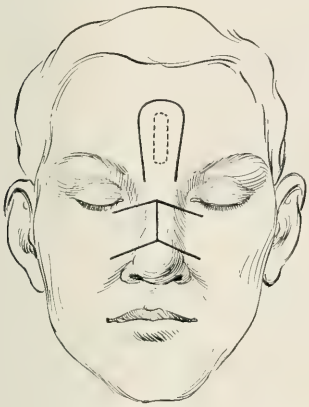


FIG. 2177.

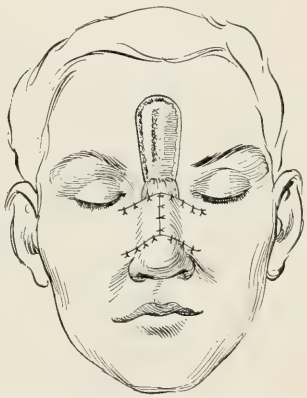


FIG. 2178.

FIG. 2177.—OPERATION FOR SADDLE-NOSE BY SUPERIMPOSED FLAPS.
The forehead flap is cut free with a strip of bone from the outer table of the skull. This becomes the lower flap, and is placed beneath the two lateral flaps.

FIG. 2178.—SUPERIMPOSED FLAPS SEWED IN POSITION.
Epithelial lining for the roof of the nasal cavity is furnished by the forehead flap.

removal of some of the redundant tissue. An incision is made at the tip of the nose just above the anterior nasal openings (Fig. 2179), and the soft tissues dissected up from the crest and front of sides as far as the root of the nose. The dissection should keep as close to the bone and cartilage

FIG. 2179.—OPERATION FOR HUMPED NOSE.
Showing incision for subcutaneous operation.

as possible. It is best done with fine scissors and a narrow knife. A sharp gouge chisel (Fig. 2180) is inserted through the opening and the hump cut off. This should be attempted only with a *sharp* chisel. If the instrument is not sharp or of the right curve, it is best to use scissors or narrow cutting

forceps. The piece of cartilage, or cartilage and bone, is removed and the middle of the wound closed. The ends of the wound may be left open for drainage. A soft gauze dressing should be applied.

Easier access is secured by a lateral incision (Fig. 2181) which should be long enough to permit dissection over the crest. If the skin flap is made too thin or is traumatized by traction or pressure in handling, gangrene is apt to occur. With care the hump may be exposed and removed without

Fig. 2180.—Sharp Gouge Used for Operation on Nose.

damage to the flap. If the wound is nicely sewed but little scar will result (Fig. 2182).

The most simple operation is by a median incision. The only disadvantage of this is that the scar is more noticeable than in either of the two other operations.

It is possible to perform the operation through incisions made from the interior of the vestibule. These incisions are made through the mucous membrane, one on either side, parallel with the edges of the nasal process of the upper jaw and just in front of them. The periosteum is then stripped up from the outer surface of the bone to be removed and the soft parts thus

Fig. 2181.

Fig. 2182.

Fig. 2181.—Operation for Humped Nose through a Lateral Skin Incision.
Fig. 2182.—Result after Hump of Bone has been Removed and Wound Closed.

undermined with a thin, narrow, sharp elevator. The projection of bone may be sawed off with a fine narrow saw. The bone may be removed or slid up or down as the case may require.

Pug-nose (retrousse nose) is corrected by removing a wedge from the septum. The wedge should have its apex well up beyond the limit of the deformity. This piece includes the whole thickness of the septum—cartilage and mucous membrane. The nose is pressed down and the space closed by sutures (Figs. 2183 and 2184). If the wings of the nostrils spread out

too far after this operation a triangular piece may be removed from each wing.

Large nostrils may be diminished in size by removing a triangular section from each wing (Fig. 2185).

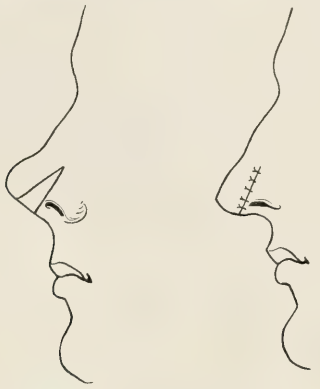


FIG. 2183. FIG. 2184.

FIG. 2183.—OPERATION FOR PUG NOSE.
FIG. 2184.—RESULT AFTER OPERATION FOR PUG NOSE.

Large lobule may be reduced in size by excising a wedge-shaped piece at the top of each nostril opening (Figs. 2186 and 2187).

Elongated lobule may be corrected by a simple elliptical incision, removing a suitable amount of the tip of the nose in the form of a wedge (Fig. 2188). The disadvantage of this operation is that a central scar results which tends to widen. F. S. Kolle devised an operation whereby the front and dorsum of the lobule is used as a flap to turn down over the wound after the removal of a quadrilateral piece of the lobule and septum (Figs. 2189, 2190 and 2191). The result of Kolle's operation is a well-formed lobule in which the shaping involves the septum as well as the tip of the nose (Fig. 2192).

Small lobule may be made more prominent by incising the tip of the nose, dissecting free a subcutaneous space, and sliding into it a shaped piece of fatty connective tissue from the outer border of the palm of the hand or from the sole of the foot. Living tissue is much to be preferred to non-viable material.

FIG. 2185. — OPERATION FOR REDUCING SIZE OF LARGE NOSTRILS.

If it is desired to lift the whole front of the nose forward, it may be done by making a V-shaped incision, each arm of the V having its upper extremity at the lower part of the nostril. An incision is made in the floor of each nostril passing downward and inward to the base of the subseptum and into the lip. This V-incision is sutured in the form of a Y, thus lifting up the septum (Figs. 2193 and 2194). Sutures are applied within the nose as well as on the lip.

Thick nasal wings may be reduced by removing from each ala an elliptical segment of tissue, including cartilage if necessary. The wound is closed without drainage (Figs. 2195 and 2196).

Thick subseptum is corrected in the same manner, by removing an elliptical segment from the septum and suturing the wound.

Misshaped nasal orifices may have their contour altered by any of the primary principles of plastic surgery. The nasal border may be shortened

Fig. 2186.

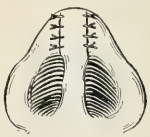


Fig. 2187.

Figs. 2186 and 2187.—Operation for Reducing the Size of Large Nasal Lobule.

by removing a wedge or lengthened by sewing a wound at right angles to the line of incision (Figs. 2197 and 2198).

Prosthetic apparatus has been used with some success to cover defects of the face. Large openings in the cheek have been covered with such prosthesis. Aluminum, gold, silver, rubber and papièr maché have been employed. Such apparatus is best adapted to reproducing the nose. An artificial nose may be made of silver, tinted to match the surrounding skin, and then japanned to fix the color. It is held in place by being attached to spectacles. Some adhesive paste, such as is used on adhesive plaster, is used to seal the edges to the skin.

Fig. 2188.—Operation for the Cure of Elongated Nasal Lobule.

Appliances such as this are used in cases in which operation is refused or contraindicated because of the presence of disease which would militate against healing of an operative wound.

Masks for facial wounds may be required in cases in which the destruction of tissue is so great that plastic operations can not remedy the defect, or in cases in which it is desired to conceal the deformity pending the performance of plastic operations. To make a prosthetic mask an impression of the patient's face is made with plaster-of-Paris. If an unhealed wound is present it is filled with gauze or cotton and covered with rubber tissue. While the impression is being made, breathing is provided for by tubes in the nose or mouth. A negative is made from this plaster impression after powdering it with chalk. With this negative a positive impression is made with plasticine. A model is then built up to duplicate the lost features. This may be guided by a previous photograph. An artificial eye may have to be added. From the sculptured model, which should represent the desired features, an electrotype plate is made. This should be of pure copper and not more than 1 mm. in thickness. The copper mask is made to fit exactly. The copper mask is then given a coat of silver plating. The contour of the edges should have especial consideration.

The mask is held to the face by strong spectacles. Rubber cement may be required for adhesive purposes at the skin edges. Elastic bands may

also be added. The outer surface of the mask should be colored to imitate the facial surfaces. A coat of spirit enamel is applied. This serves as a ground upon which to apply the flesh colored pigments. The painting

FIG. 2189.

FIG. 2190.

FIG. 2191.

FIGS. 2189, 2190 AND 2191.—KOLLE'S OPERATION FOR ELONGATED NASAL LOBULE.

of the mask should be carried out on the face and the pigmentation continued onto the natural skin. By using a cream-colored ground the tinting may be applied to this and dull or oily effects secured by powder or by rubbing the

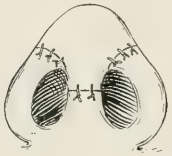


FIG. 2192.—RESULT OF KOLLE'S OPERATION FOR ELONGATED LOBULE.

surface. Eyebrows of real hair may be pasted to the mask. Eyelashes may be made by soldering on a strip, bearing a series of very fine wires or bristles.

FIG. 2193.

FIG. 2194.

FIGS. 2193 AND 2194.—OPERATION FOR SMALL NASAL LOBULE.

Cosmetic treatment of facial paralysis has been carried out with some success by Busch and Momburg in a number of cases. They carried a loop of silver wire through the soft parts of the cheek from the corner of the mouth

around the malar bone. The wire draws up the drooping corner of the mouth and greatly improves the expression.

Cosmetic treatment with tallow has been successfully practised. The tallow is made of mutton fat. Holländer used a mixture of human fat and mutton tallow. The material is sterilized and injected with a syringe. The smaller the amount of human fat in the mixture the slower the absorption. Human fat may be obtained from lipomas.

Operative treatment of prognathism may help to bring the teeth into better alinement and improve the appearance of the face by reducing the size of

Fig. 2195.

Fig. 2196.

Figs. 2195 and 2196.—Operation to Remedy Thick Nasal Wings.

the lower jaw. People with a protruding lower jaw are suffering more from deficient development of the upper jaw, and this is best remedied by orthodontic measures in youth. Operation on the adult may be employed to reduce the size of the lower jaw, although from a cosmetic standpoint, it is apt to produce a weak-looking face. A rhomboid section is removed from each side at the angle posterior to the molar teeth. The operation is done through an incision along the lower border, and if possible the mucous membrane not opened. When the last molar tooth requires to be removed, opera-

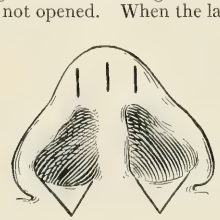


Fig. 2197.

Fig. 2198.

Figs. 2197 and 2198.—Operation to Correct Misshaped Nasal Orifices.

tion should not be done till the extraction wound is healed (see Surgery of the Jaws, Vol. II, page 280; and Operations on Bones, Vol. I, page 717).

PARAFFIN PROSTHESIS

Paraffin may be injected into the tissues to give plumpness or to cause pressure in cases in which the same result can not be secured by living tissue. Its use is far from desirable, and it should be resorted to only as a confession of defeat when more sound surgical measures are not available. It is described here, not to be recommended but because in certain rare instances it must be resorted to. Every surgeon who has used it extensively, sooner or later has encountered disastrous results. Most surgeons

condemn it utterly. The transplantation of living fatty tissue has quite supplanted paraffin among competent surgeons.

The injection of vaselin or soft paraffin at body temperature into the dilatable tissues of the body causes some irritation. It forms a mass which produces dilatation equal to its bulk, and may lie in the tissues indefinitely. The first uses to which this method was applied were for cosmetic purposes about the face. Saddle-nose, depressions following the extripation of tumors, congenital depressions, wrinkles of the skin, and defects following loss of maxillary bone were among the conditions in which this method was first employed. It was used also to give plumpness where needed for the sake of better symmetry. Later it came to be employed as an aid to deficient sphincter action at the various orifices, and to produce pressure in controlling discharges.

The field of application of this principle is not wide. For improving the symmetry of the facial parts it has had its largest application. By making small, repeated injections almost any desired contour may be secured. A fundamental principle is that a general anesthetic should not be used, because the amount of paraffin injected should never be large enough to cause pain. If the pressure in the tissues is so great as to cause pain there is danger of sloughing. The paraffin mass should not be large enough to produce this pressure symptom. Repeated injections of small amounts, therefore, are the least objectionable.

In some localities it is desirable to free the skin which is to cover the paraffin by introducing a very delicate knife. The opening made by the knife may be closed by a suture, and the needle for the injection introduced by the side of the stitch.

The paraffin should be sterile, and the operation conducted with the strictest observance of the principles of asepsis. Skill and experience serve to eliminate the immediate untoward results which are possible in this, as in all operations, but the later untoward results, which may be quite disastrous are entirely beyond the control of the surgeon.

The paraffin mass becomes more or less absorbed in the course of a few months and is replaced by connective tissue embracing scattered collections of paraffin. Even a solid mass of hard paraffin in time usually becomes split up and permeated by connective tissue, which ultimately replaces it.

The material used is pure paraffin diluted in white vaselin. The paraffin should have a melting point of 43°C. (110°F.) A range between 42°C. and 45°C. (108°F. and 113°F.) is best. Paraffin which is solid up to 49°C. (120°F.) is difficult to use in a syringe; and paraffin which becomes soft under 40°C. (104°F.) does not keep its form well and is apt to become dissipated in the tissues.

It was once the custom to heat the paraffin and inject it in its melted state allowing it to cool and harden in the tissues. The cold method is now used, the paraffin being forced out of the syringe in solid form. Pure paraffin melts at about 49°C. (120°F.) For the cold process the following formula is recommended: Pure paraffin, 1 part; white vaselin, 8 parts. This amount of vaselin brings the melting point of the paraffin down to about 43°C. (110°F.). A mixture can now be bought having this melting point.

This mixture is placed in a receptacle in a hot-water bath and heated, being stirred the while. It is then poured into sterile test-tubes holding 8 c.c. (2 drams), stopped with rubber corks and the corks coated with paraffin. The test-tubes should be filled nearly up to the corks, as warm air after cooling may cause such rarefaction that the pressure of the corks will break

the glass. When a tube is to be used it is sterilized in a rheostat, sand bath or hot-water bath and poured or drawn up into the syringe. If the heat is not evenly applied the fluid is easily burned to a brown and spoiled. With care exercised, the test-tube of mixture may be sterilized by heating over a spirit lamp.

Many surgeons prefer cold paraffin without vaselin. This melts at about 49°C. (120°F.). It is used in a syringe which is strong enough to press it out through the needle. Lagarde added little bismuth to the paraffin to permit *x*-ray examinations of the prosthesis (Presse Médicale, Feb. 24, 1912). Paraffin with a melting point of 65 or 70°C. (149 or 158°F.) is used by some surgeons, heated to 6°C. (10°F.) below its melting point when injected.

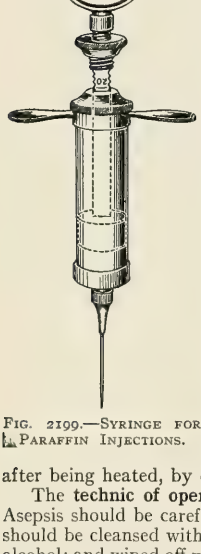


FIG. 2199.—SYRINGE FOR PARAFFIN INJECTIONS.

The best **syringe** has a metal barrel, as glass is apt to break. The piston also is of metal. It should be capable of standing great pressure. The piston should be operated by direct pressure of the thumb; but it should be so constructed that a thread on the piston rod may be made to engage in a nut on the barrel so that screw action may also be brought to bear in exposing the contents if it is desired (Fig. 2199). The syringe should hold about 10 c.c. (2½ drams). About 8 c.c. (2 drams) of the paraffin-vaselin mixture should be poured in the syringe.

The syringe and its contents should be placed in sterile water at 21°C. (70°F.) and allowed to cool down to that temperature. By this treatment the paraffin mixture becomes solid. As the piston is pressed down the mixture is forced from the end of the needle as a white thread.

The needle should be of good caliber and not longer than 2.5 cm. (1 inch). It should not be of knife sharpness; the sharper the needle the greater the danger of puncturing a vein. The syringe should have a solid metal piston. This has the disadvantage that it expands when heated more than the barrel. The piston can be made smaller, after being heated, by dipping it into cold sterile water.

The **technic of operation** is the same as for other surgical procedures. Asepsis should be carefully observed. The skin over the field of operation should be cleansed with soap, warm water and a gauze sponge; washed with alcohol; and wiped off with sterile water or antiseptic fluid. Or the ordinary iodin sterilization may be used.

The syringe being filled, all air should be expelled. Any mixture of air in the paraffin causes explosive sounds during the injection, and forces air into the tissues, which causes unequal swelling, and seriously interferes with the operation. The syringe and contents should be allowed to cool to cause uniform solidification of the paraffin. The needle should be slightly warmed 39°C. (103°F.) before its introduction.

The skin is picked up by the fingers of the left hand, and the needle passed into the subcutaneous connective tissue. The point of the needle should be passed to the furthest side of the area to be filled so that the injection may be made as the needle is withdrawn. It is well to have the fingers of an assistant press the skin at the periphery of the area to be injected in order

to confine the fluid to its goal. The screw of the piston is rotated and the paraffin forced slowly and evenly into the tissues.

Pain should not be caused, except by the prick of the needle. Only enough should be injected to cause correction of the defect. Before withdrawing the needle, a reverse turn of the screw should be made to remove the pressure in the syringe. If the needle is withdrawn while paraffin is exuding from the needle, the needle tract in the skin will be filled with paraffin, which is apt later to cause infection or produce a sinus.

The tip of the gloved finger is placed over the opening and the mass under the skin moulded into the desired shape by manipulation with the fingers.

The needle puncture is sealed with a drop of collodion in ether, and the patient instructed to apply cold compresses if pain or undue swelling appear.

Cosmetic injections are at first effective when skillfully done. Several sittings are often necessary. Several punctures may be made at the same sitting. For cosmetic purposes paraffin is used under the skin of the face, neck, shoulders and breasts. Skin that is bound down by scar or dense connective tissue should be divided by a subcutaneous incision with a narrow knife before the injection is made.

The advantages of this treatment are that deformity is corrected without scar, the patient may at once return to work, anesthetic is not required and dressings are not necessary.

The **general surgical uses** of paraffin injections are those in which the pressure or enlargement of a foreign mass is desired.

This method has been used in *incontinence of urine* due to weak sphincter of the bladder. The injection of paraffin into the sphincter around the neck of the bladder has given relief. This is done in the female through the vagina.

The same principle has been applied in the treatment of *incontinence of feces* on cases of artificial anus or damaged anal sphincter.

Injection of the turbinate bones in cases of atrophic rhinitis has been done with success.

In the treatment of *ozena* paraffin injections have given good results. Hard paraffin, melting at 52°C. (125°F.), is used. The mucous membrane of the inferior turbinate and septum is first injected with water to lift it up and make it more succulent. The paraffin is injected after the water has been absorbed.

Injections for *uterine prolapse* have been done with poor success.

Injections for *hernia* have given early success in some hands, but this treatment is far inferior to radical operation. Some surgeons have found it of value in treating small umbilical hernia—not larger than 1 cm. (⅜ inch) in diameter. The sac is lifted up, the tip of a short needle inserted and 3 or 4 c.c. of hard paraffin injected. Some disastrous results have been reported; and the method should be condemned.

The complications and disadvantages of paraffin prosthetic surgery have been so serious in all hands as to discourage its use. A foreign body in the tissues is never an ideal result of surgical procedure. The presence of the paraffin causes irritation which results in the deposit of fibro-connective tissue. The permanence of the result is better insured when the paraffin is injected in such solid form that it is extruded as a thread, and connective tissue can grow between and separate it. If it lies as a solid mass, it is most apt to make later trouble.

Paraffin *embolism* has occurred and produced death. It is due to the injection entering a vein. Pulmonary and cerebral embolism have been observed. Most of these accidents have been reported in cases in which a

low melting point was secured by the admixture of vaselin with the paraffin. Blindness from embolism of the optic nerves has followed injections for saddle-nose in a considerable number of cases. *Phlebitis* has been reported by several surgeons. Puncture of veins of the neck and injection into the blood stream is apt to be fatal. A number of such cases are reported. This accident is avoided by using a not too sharp needle. As an extra precaution, the needle may be introduced alone before it is attached to the syringe; blood not flowing, the syringe may then be connected and the injection made.

The injection of air, and the formation of *air embolism* is prevented by emptying the syringe of air before operating.

The prevention of *infection* and *abscess* is by applying the general principles of surgical asepsis.

A certain amount of *irritative reaction* is bound to occur. Impure paraffin or infection may exaggerate it. Cold applications may be relied upon to allay the simple mechanical reaction.

When too much is injected, the pressure may cause *necrosis* and *sloughing*. This is especially apt to occur in patients suffering with constitutional diseases which interfere with the vital resistance.

When too much material has been injected, and disfiguring *swelling* occurs and persists, the best thing to do is to cut down upon the mass, preferably at one side, and remove as much of it as possible together with the new connective tissue. The wound should be closed; and, if necessary later injections may be made.

The *escape of paraffin* at the needle hole has been discussed under technic above. It is a serious complication.

Ultimate *absorption* and disappearance of the paraffin takes place. The tendency of the remaining connective tissue is to contract. When this has occurred further operations may have to be done to restore the defect.

A persisting *redness of the skin* may follow too large an injection. If it is not necessary to remove the mass, the external application of a 20 per cent. solution of ichthyol may be used.

The production of a *hyperplasia* with excessive connective tissue deposit, as a result of the injection, sometimes causes overcorrection. This sometimes accompanies the organization of the paraffin, and seems to be due to a special reaction of the tissues to the presence of the paraffin. Even after removal of some of the mass, the hyperplasia continues, and is only cured by extirpation of all of the newgrowth and the paraffin which it envelops.

The *diffusion* of the injected material beyond the area of operation sometimes occurs. In cases of saddle-nose the injection has spread to the cheeks and eyelids. Some very unfortunate and unexpected results of this sort have been reported. When to this diffusion is added hyperplastic deposit of tissue a sad result is produced.

In some cases a *yellow discoloration of the skin* takes place which persists indefinitely.

Nervous disturbances such as *hypersensitiveness of the skin*, *numbness*, and *headaches* have followed injections about the face.

As one contemplates the *complications* and disadvantages of hydrocarbon prosthesis, it is evident that experience, skill, and great pains are the guarantees of success. This method had its vogue, and was used largely by charlatans. Surgery has since been occupied in cutting out from the unhappy victims many of these misshaped masses of paraffin. The method has a very limited field of usefulness.

DISTORTIONS AND CONTRACTIONS FOLLOWING WOUNDS, BURNS AND ULCERATIONS

These deformities should be prevented by securing prompt epithelial covering for denuded skin surfaces because a surface, denuded of epithelium, continues to deposit scar tissue; and the tendency of scar tissue under the skin is to contract and cause (1) deformity and (2) occlusion of blood-vessels. In old ulcerated surfaces the deposit of scar tissue may extend through the muscles even to the bone. It does not suffice in such surfaces, following burns, to secure ultimate epithelization; but an *early covering with skin* is the essential. Large surfaces, even though ultimate healing may be expected, should be covered by plastic operation; for weeks and months of healing are no longer justified.

In treating tightly stretched and scarred skin, which is poorly nourished and easily becomes cold, and in which ulcerations develop from slight abrasions, good results are secured by **relaxation incisions.** The operation is simple. It is best not done in he presence of ulcers, but ulcers need not contraindicate operation, provided they are sterilized before operation. An incision is made at a right angle to the direction in which it is desired the skin should be relaxed. The incisions should be long, and should preferably run in the directions of the blood-vessels. After the incisions are made the wounds gap and the skin which had been in a state of tension takes on a more normal appearance. Such wounds sometimes gap, 4 to 8 cm. (1½ to 3 inches). The incisions may be made parallel to one another. One or several may be made. The wounds may be skin grafted at once or later, depending upon the state of the wound.

When the distortions from contracted scar tissues have not been prevented, and are very old something still may be done to correct the deformities. The plastic operations which have been described may be employed. Where there is so much underlying scar tissue that the skin constantly breaks down because of defective nourishment and relaxation incisions fail, it is best to make a deep dissection and remove the diseased skin, getting down to healthy tissue, which may be covered with grafts of whole skin.

The various operations for sliding flaps, transplanting skin, and changing contours may be called upon.

Multiple incisions may be made transverse to the line of contraction 3 mm. (⅛ inch) apart. These incisions should pass through the whole thickness of the skin, and extend into the healthy skin at their extremities. Bleeding is checked by pressure, and a 5 per cent. solution of *thiosinamin* is rubbed into the wounds. The dose of this drug is 0.06 Gm. (1 grain); therefore fully 1.25 Gm. (20 minims) may be used. The parts are put up stretched by splint or bandaging. The operation may be repeated 3 or 4 times with intervals of two or three weeks between each operation.

Moist warm packs, continued for a long period, have decided value in softening and stretching scars. The moisture must be constant. The parts should be enveloped in compresses of gauze wet with boric acid solution. A rubber covering should be placed over it to seal it and prevent evaporation. Once a day warm water should be added to supply constant moisture. During this treatment the parts should be put on the stretch as much as can be tolerated. This is accomplished by splints or by adhesive strips. After a few days, daily massage, pressure, and kneading should be applied through the dressing. Later the dressing may be removed daily and the massage and stretching applied directly to the skin. For operative treatment of the skin deformities, see Plastic Operations, page 622; See also Contractures of Joints, Vol. I, page 682.

INJURIES OF THE NEWBORN

Both the natural and artificial traumatisms of childbirth may cause injuries requiring surgical treatment.

Operations on infants require the use of every possible measure to prevent depression and shock. The essentials are that loss of blood should be prevented, the body should be kept warm, and traumatism should be as slight as possible. The child's organism is delicate; and a small amount of offense may cause death.

Caput succedaneum, the edema which occurs on the only part of the body which is not subjected to pressure in delivery, requires no surgical treatment except that it be spared the inadvertence of being mistaken for hematoma or some other incisable swelling. In other words, it should be treated to freedom from surgical attentions.

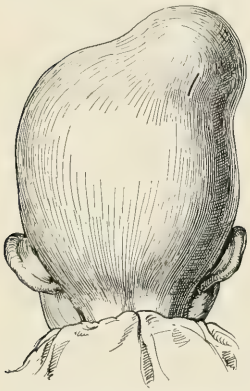


FIG. 2200.—INCISION FOR HEMATOMA OF SCALP IN THE NEWBORN.

Cephalhematoma, usually a subpericranial effusion of blood, may also be located under the cranium. The common effusion of blood under the pericranium, if it present no unusual features, may be left alone to be absorbed. If after ten or fifteen days there is no evidence of subsidence of the mass, it is best to open it. The head should be cleansed, the scalp shaved and aseptic-ized, and a small incision made at the base and directed toward the summit (Fig. 2200). If the clots do not escape easily they may be broken up by introducing a blunt instrument. Pressure evacuates the sac. A flat compress, held by a bandage, should be laid upon the scalp, to make gentle pressure.

Intracranial hemorrhage not uncommonly occurs in instrumental deliveries and in prolonged and difficult labors, and, unless prevented or cured, produces "birth palsy" or mental derangement. The tentorium is often found lacerated. Prompt intervention will save many of these children. Cortical symptoms, involving the facial and limb muscles, point to clot above the tentorium. Spinal irritation, rigid extremities, priapism, and somnolence point to clot below the tentorium. When the clot is above the tentorium the great fontanel bulges, and the child is restless and screams. Later the reflexes become paralyzed and the child is quiet. Too many of these cases are never recognized but go on without treatment.

Therapeutic measures to be of service must be applied early. The treatment is the same as for intracranial hemorrhage in the adult. It consists briefly in removing the clot. It is indicated in all cases. If the symptoms are pronounced enough for diagnosis, serious permanent impairment of brain function may be expected unless the clot is removed. This should be done within the first week or two after birth, otherwise the clot

becomes organized and the changes in the brain become permanent. Later operations to remove the scar, left by the clot, are of no avail.

After localizing the clot, operation conducted with care to prevent shock need not be a serious matter. At the worst, it is less serious than the disease. These cases may be operated upon from the second to the twelfth day of age. In some it will be found necessary to operate on both sides of the head; and in some cases secondary operations will be necessary.

The child's head should be shaved and cleansed. The whole body is best wrapped in cotton, and kept warm by artificial heaters. Light chloroform anesthesia is used. A tourniquet of thin elastic rubber tubing, tied to make a circle, is held by a tape to prevent its displacement. A horse-shoe-shaped incision is made just inside of the margin of the parietal bone about 1 cm. (⅜ inch) from the suture. The base of the flap is toward the base of the skull. The incision goes down to the bone. With a delicate elevator the periosteum and scalp are elevated so as to expose the suture at the margin of the parietal bone. The edge of the parietal bone is lifted up with an elevator, and thin bone-cutting forceps are introduced. The parietal bone is cut in the line of the scalp incision. The bone is then broken across at its base.

A subdural hemorrhage shows itself as a dark discoloration through the dura mater. If this condition is found the dura should be opened by a curved incision with its convexity downward and some distance from the edge of the bone wound. The flap is turned up and the clot gently scraped away or washed out with a gentle stream of warm salt solution. The dura should be sutured back in place with catgut, and the bone-scalp flap replaced and sutured. Drainage is not necessary. The suture of the dura should be accurate to prevent adhesions to the brain. Bulging of the brain which prevents suturing the dura may be relieved by drawing off cerebrospinal fluid by lumbar puncture.

Fractures in the newborn should be treated by the same principles as apply to the adult. The small size of the limbs often makes this difficult. Because of the weakness of the muscles there is not the displacement which characterizes the adult. The muscles serve as a padding about the bones. They have the property of a splint, and are an advantage rather than a disadvantage. Surprisingly good results follow the most simple attention to position. If the limbs are kept fairly straight the bones tend to unite in good position (see Fractures of the Newborn, Vol. I, page 529).

Injuries of the bones of the skull require special consideration. *Simple indentation*, without fracture, tends to undergo spontaneous cure by the natural pressure within the skull. The outward force of the growing brain tends to cure the depressions which have not been more promptly overcome. It is best not to rely too much on nature in these cases. If the depression is considerable, or if a slight depression does not disappear in a week or ten days, it should be operated upon (Fig. 2201). A case in which the depression is over the motor area or over the frontal lobes should be operated upon with even less time being given for natural cure.

Operation consists in making a small opening through the skull at the outer margin of the depression, introducing through it a thin elevator, such as the handle of a flat-handled knife, and elevating the bone.

In old depressions, such as this, which have become fixed, it becomes necessary to make a small trephine opening at the middle of the concavity, and introduce into this opening two right angle retractors for making traction. But a moderate amount of pull should be applied to these. If the bone is not replaced with facility, circular counter-pressure should be made at

the periphery of the depression while the elevating force is applied. These measures failing the treatment for depressed fracture should be applied (see Fractures of the Skull, Vol. I, page 532).

For **fracture of the femur** the treatment has been discussed under fractures (Vol. I, page 529). The thigh may be put up strapped to the trunk or in a simple side-splint. The Thomas knee splint is another useful device. The leg may be put in this splint, well padded, pulled down and bandaged, and the dressing covered with rubber protective. If indicated adhesive straps may be used as in the adult, and connected to the lower end of the splint by means of elastic bands to make slight traction.

Fractures of other bones may be treated as in the adult (see Fractures of the Newborn, Vol. I, page 529).

Dislocations occur especially at the shoulder and hip-joints. Usually they are due to traction or distortion at time of delivery, and should be rec-

FIG. 2201.—DEPRESSION OF SKULL IN NEWBORN INFANT WHICH SHOULD BE TREATED BY OPERATION.

ognized and corrected as soon as possible. If they become "old dislocations" they should be corrected by operation (see Congenital Dislocations, Vol. I, page 613).

Fractures of the trachea should be watched, and tracheotomy done as an emergency operation if necessary to save life in the event of dyspnea from edema, pressure or hemorrhage.

Brachial paralysis, due to lateral flexion of the head and traction on the arm, if operation is necessary, should usually be operated upon when the child is one month old. Most surgeons have advocated operation a year or two after the beginning of the paralysis upon the ground that this gives time for spontaneous recovery, if it is going to take place and because a child one or two years old is a better subject for operation. By the end of the first month the surgeon should be able to determine whether the palsy is due to nerve lesion or no. If there is an actual rupture of nerve trunks the sooner they are sutured the better. To delay a month or a year will only

mean more permanent disorganization of the nerve. This is determined by the electrical reaction.

In children at this tender age, exposure of the plexus is not difficult. An oblique skin incision passing from above downward and outward in the direction of the natural folds of the neck is made. It is about 2 cm. above the outer end of the clavicle and nearly horizontal. The incision should be about 4.5 cm. (1¾ inches) long and lie in the posterior supraclavicular triangle. The external jugular vein is crossed by the incision. It should be retracted forward. The operation proceeds as for exposure of the plexus in the adult (see Brachial Plexus, vol. I, page 892). Every drop of blood possible should be saved. Usually not all of the trunks will be found ruptured. The scar tissue should be dissected away. The nerves should be sutured with the finest possible thread. The threads should all be passed, and then the arm elevated and the hand placed on the opposite side of the head, to elevate the shoulder, before the sutures are tied. The wound should be closed and the arm fixed in this position with a plaster-of-Paris bandage.

So-called brachial palsy is usually not a primary nerve disease. In a large proportion of cases the paralysis of the upper extremity of the newborn is due not to rupture of the brachial plexus but to injury of the shoulder-joint which produces an exudate which involves the structures of the axilla. Serum, blood and synovial fluid produce the inflammatory deposit along the cords. Electrical examinations usually show no nerve paralysis after two months. These cases which show at operation thickening and scar about the cords of the plexus, should not be mistaken for cases of rupture of the cords, as rupture is exceptional.

Reduction of dislocation should be easy after birth. This is the important thing in the treatment of these cases. These children often grow up with palsied arms, and may be cured by operating on the shoulder-joint for complete or partial dislocation, for adhesions, or for old lacerations of the joint capsule. Dislocation can be reduced in the very young, if seen early, without operation. After the child is two years old operation will have to be done in most cases.

Operations in early infancy are very rarely indicated. Most cases of apparent brachial palsy, due to birth injury of the shoulder, if not due to dislocation, will recover if the child's arm is put up in a sling with the forearm lying across the front of the body. The child should be treated by passive motion and massage daily.

Wounds of the fetus, if uninfected and not followed soon by delivery, heal promptly. Nothing can be done till the child is born. A child stabbed through the abdomen, and having its intestine cut in two by a knife which pierced the mother's abdomen and womb, later was born, and the divided bowel ends which had become sealed by nature were exposed by operation and united.

Children *in utero* suffer *amputation of limbs* by strangulation by the cord. In these cases something may be done. The muscles may be brought out and a cineplastic stump made to give better function as the child grows (see Cineplastic Amputations, page 526).

Spastic paralysis due to hemorrhage may be treated, in selected cases, by operation for cerebral decompression. The cases which give a history of difficult labor, and which show the signs of increased intracerebral pressure, should be operated upon with the hope that the spasticity may be lessened and the mental condition improved. The presence of pressure should have been determined by ophthalmoscopic examination and lumbar puncture.

The most promising cases for operation are those which have not suffered mental impairment.

Decompression is done first on the right side of the head. A vertical incision 6 or 8 cm. (2½ or 3 inches) long, is made from the parietal eminence down to the zygoma just in front of the ear. The temporal fascia is incised and the fibers of the temporal muscle separated by blunt dissection. A small opening is made in the squamous portion of the temporal bone with a burr. This is enlarged with rongeur forceps until it is 5 to 8 cm. (2 to 3 inches) in diameter. The dura is opened by an X-incision. The wound in the temporal muscle and fascia is sutured with chromic catgut. The scalp wound is closed with silk.

This operation permits the brain to expand. If the intracranial pressure continues high after the operation, the same operation is done on the left side after a week or ten days.

The measures for dealing with deformities and spasticity should be applied. Muscle training, massage, exercises, muscle stretching, tendon lengthening, and tenoplasty will be called for.

ELECTRICITY AND RADIATION IN SURGICAL TREATMENT

ELECTRICITY

The therapeutic uses of direct currents of electricity in surgery are confined largely to stimulating weakened muscles, and to the destruction of tissue. The faradic and galvanic currents are used for the former purpose. Their application is discussed under Nerves and Paralysis of Muscles. Electricity is also used to furnish power for propelling instruments and for light.

For the destruction of tissues electricity is used in the form of the thermocautery and in high-tension currents to permeate the tissues.

The **thermocautery** performs the functions of the hot iron which was originally used. A current of such high power is passed through the end of cautery instruments that the metal is heated to a glowing heat. Special instruments are made for this purpose (Fig. 2202). In using the cautery the surrounding tissues should be protected from the heat. This may be done by surrounding the area to be cauterized with wet sponges. The cautery should not be applied continuously because the heat may penetrate and cook the structures in a larger zone than is desired. It should be applied intermittently, touching the tissues with the hot point and then removing it for a few moments. For ordinary destructive cautery work, the instrument should be heated to a cherry red rather than to a white heat (for further discussion see Thermocautery Treatment of Cancer, Vol. I, page 331; and Cautery Treatment of Cancer of Uterus, Vol. III, page 422). The cautery is of especial value in treating cancer of the uterus, and it is described with particular reference to that disease.

Fulguration is a method of treatment for stimulating the tissues by means of high-frequency electric sparks. It was devised by De Keating-Hart, who modified the method of Rivière. The current is obtained through an induction coil and intensified by means of Leyden jars or the Oudin resonator. By these means a unipolar current is generated. The high-frequency alternating current gives one to two million oscillations per second. The monopolar Oudin current causes superficial destruction of tissue. The bipolar current of d'Arsonval causes deep destruction. The unipolar instrument used for ordinary external applications to a bloody field consists of a hollow hard rubber tube about 36 cm. (14 inches) long, tapering toward the end where it is about 6 mm. (¼ inch) in diameter. It is provided with a rubber handle. A hollow metal tube about 20 cm. (8 inches) long is inserted into the larger end of the rubber tube (Fig. 2203). To the end of the metal tube is attached a wire which occupies the rest of the rubber tube. The length of the spark is regulated by moving the inner tube back and forth. The object of the hollow tube is to blow compressed filtered air upon the wound. This blows away blood so that the sparks act directly upon the tissues, and at the same time the air current keeps the rubber tube from being burned.

For deeper structures and for applying the current in body cavities a hollow tube is not used, but instead a simple metal conductor covered with rubber, the metal projecting slightly at the end.

The tissues are bombarded with the long high-tension electric sparks

which fly from the point of the conductor into the tissues. The object is not to cauterize or destroy the tissue, but to apply only enough of the current to stimulate the healthy tissues to higher resistance and to devitalize the cancer cells. This is the theory of the action of fulguration in cancer.

The treatment may be applied to the wound after operation for cancer. If all of the growth has not been removed, fulguration may prevent or delay recurrence. It is used also in the direct treatment of cancer which is not deep and which can not well be excised. Cancer of the skin may be cured by this method, with surprisingly little scar remaining. In papilloma of the urinary bladder, it has given better results than any other method of treatment.

The *technic* is simple if the proper instruments are at hand. Electric current may be secured from the ordinary municipal supply, dynamos, or other electric generators. A transformer coil, a condenser with a spark gap, and a resonator (Oudin) are the essential intermediary apparatus. It is

Fig. 2203.—Fulguration Electrode. (*Keen.*)

desirable, but not necessary, to have a part of the patient's naked body in contact with the metal parts of the table.

The apparatus should be able to produce at the end of the solenoid of the resonator a spark 7 or 8 cm. (3 inches) long. In applying the sparks, the tip of the metallic applicator is drawn into the hollow rubber tube and the current of air and the sparks are directed toward the area to be treated. This prevents dissipation of the sparks where they are not wanted.

A spark 10 cm. (4 inches) long was formerly used. Now the best results are secured with a 1- to 3-mm. spark. The smaller the spark-gap, the less pain and hemorrhage is caused. The spark should not be visible. The electrode should be moved constantly so that too intense action, which would cause burning, is not concentrated upon any one spot. The application should last five or ten minutes. When applied to a wound surface numerous dark spots, which are due to coagulated blood, appear.

In treating *papilloma of the urinary bladder*, but little resistance in the rheostat is required, and the shortest possible spark-gap—usually not more than 1 to 3 mm. A high-voltage and a large spark-gap cause pain, and an unnecessary violent destruction of tissue which rapidly obscures the field of vision. It is found that the current is less painful, more destructive, and

has less tendency to short circuit when the points of the spark-gap are kept bright. A single strand of steel wire suffices as an applicator. It should be stripped of insulation for a distance of 2 to 5 mm. at its tip. This exposed part of the wire is thrust into the tumor or against it. An operating cysto-

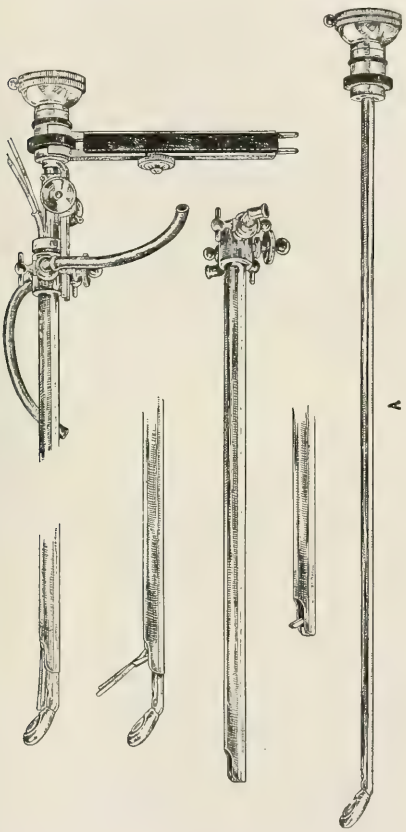


FIG. 2204.—CATHETERIZING AND TREATMENT CYSTOSCOPE OF P. M. PILCHER.

The upper figure shows the instrument with catheters in place, and irrigating tubes and electric connection. The various ends of the instrument, with catheter and deflector protruding, are shown below. The lower figure is the telescope part of the instrument shown alone. For high-frequency electric treatment the insulated wire is passed through the catheter canals.

scope is used (Fig. 2204). A special fulguration catheter is made, which may be introduced through a catheterizing cystoscope. The tumor need not be punctured by the electrode (Fig. 2205).

A double catheterizing cystoscope may be used if necessary. As the electrode is inserted in the tumor and the current turned on, bubbles appear and a blanching of the tumor is observed (Fig. 2206). So long as the elec-

trode does not come close to the bladder wall the operation is without pain. This serves as a guide, the sensations of the patient informing the surgeon whether the electrode is applied to the tumor or has slipped away and lies against the bladder wall.

FIG. 2205.—CYSTOSCOPIC VIEW OF ELECTRODE APPROACHING PAPILLOMA.
Note the short end of uncovered wire emerging from the insulation. (*From P. M. Pilcher.*)

A contact at each point may be maintained for about a minute and then moved to another point. In the event of the field becoming obscured by blood, the bladder may be washed out and the treatment resumed. The

FIG. 2206.—CYSTOSCOPIC VIEW OF ELECTRODE ENGAGED IN THE GROWTH.
The current is turned on as evidenced by the blanching of the tumor and the appearance of bubbles of gas. (*From P. M. Pilcher.*)

operation may be continued with contacts of thirty to sixty seconds until a papilloma is reduced to a whitish mass.

Operating without using an anesthetic is advisable, because of the advantage of having the patient's sensations as a guide. In large growths it is

advisable to make applications every seven to fourteen days. As the tumor becomes smaller, and the applications must be made against the bladder wall, longer intervals are necessary, because the area of edema which surrounds the growth may be mistaken for tumor unless time is given for it to subside. The first treatment should not be prolonged or give the patient discomfort lest he be discouraged from further applications.

If the pedicle can be discovered, it is best to apply the treatment there. The treatment should begin at the periphery in sessile growths. Small growths may be cured by one or two thorough sparkings. A pedunculated growth may be removed by operation and the sparking applied to the stump. The slough comes away in from two to four weeks.

The results in papilloma of the bladder are most gratifying and better than with any other method of treatment. Under a few applications of fulguration the tumor disappears. Repeated cystoscopies should be made to discover recurrence.

This is the method of choice in the treatment of benign papilloma of the bladder.

Many genito-urological specialists advise against resections of the bladder wall in treating tumors; if treatment through the cystoscope is ineffective, suprapubic cystotomy should be done, the tumor destroyed with the actual cautery, and deep penetration of the base by the bipolar spark of d'Arsonval employed. The general surgical opinion is that localized cancer should be removed by resection, and recurrences treated by the bipolar spark.

Besides the unipolar current, the bipolar current of d'Arsonval is also used. This requires the fulgurating electrode and a second flat electrode which is applied to the buttock or other surface of the body near the disease. A current of 200 milliamperes is used for treating papilloma. One pole is buried in the tumor. It causes a charring of the entire surface of the tumor.

The monopolar current is effective in the treatment of *polyp* of the bladder and urethra. It is the best known agent for the treatment of *venereal warts*, *chancroids*, and *herpetic ulcers*.

For the treatment of *cancer of the uterus*, fulguration has proved very effective. It can be applied without anesthetic. Particularly good results are obtained when fulguration is combined with the acetone treatment.

The x-rays in surgical treatment followed the discovery that the rays had the power of destroying tissue, and in smaller doses the power of stimulating tissue. So much information has accumulated in this branch of treatment that only the specialist in *x*-ray work can be regarded as thoroughly competent in its administration.

The rays are the emanations from the cathode pole of a Crooks vacuum tube when traversed by a high-tension electrical discharge from the Ruhmkorff coil (Fig. 2207). The peculiar rays discovered and described by Röntgen have the physical property of penetrating animal and vegetable substances, being stopped especially by minerals. They are different from the heat rays and the light rays.

When applied too long or with too great intensity to the skin, changes are caused which have the appearance of a dermatitis. These so called *x-ray burns* tend to break down and leave ulcerated areas and to undergo degeneration into a form of epithelioma. Exposure of the testicles and ovaries to the *x*-rays results in sterility from inhibition of the function of these organs. It has been shown that the growth of tissues can be impeded by the rays. In young animals the growth of one leg may be checked by exposing it to the rays. Internal organs are also affected, and it is possible that nephritis has been caused by such exposure.

In using the *x*-rays the operator should protect himself. This is done by operating the apparatus from within a lead-covered booth arranged with mirrors so that the operator may see but not be in line with the cathode radiations.

The *x*-rays have been used in the treatment of almost every known disease of the skin; and a vast amount of undigested and premature material has accumulated. It is doubtful if its field is as great as has been assumed by some enthusiasts. The dosage is hard to regulate and the effect is so delayed that much of the work must be done with uncertainty.

The dosage is regulated by the radiometer or the pastilles and the sensitive scale of Holzknecht. Small doses were once used, but as better control is secured, massive dosage is being more employed. In epithelioma 8 or 10 Holzknecht units are applied. Smaller dosage—2 to 6 units—are used in skin diseases.

For *treating deep disease*, such as cancer, hard tubes should be used. About 500 × units are required at the deep focus to be effective. To secure this penetration, fully 3500 × units must be applied to the skin, since only about one-seventh of the rays which play upon the surface penetrate deeper

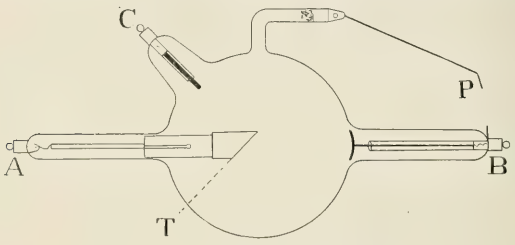


Fig. 2207.—X-Ray Tube. (*Tousey.*)

than 10 cm. (4 inches). This strong dosage causes but little skin disease. The distance from the focus may be 10 or 15 cm. The exposure in twenty-four hours may total from 60 to 120 minutes. The cross-fire technic should be used. This consists in directing the rays toward the center of the diseased area from as many angles and through as many different areas of skin as possible.

For treating *osteosarcoma* of bones the rays must have good penetrating power, equal to 7 to 8 of the Benoist scale. The dosage of each treatment should be measured. This is done with the radiometer. If a dose capable of producing erythema has been given, that skin area should not be exposed again for at least two weeks. Filters should be used to protect the skin. For this purpose a piece of sole-leather, 3 mm. (⅛ inch), and from 1 to 3 mm. of aluminum are used. The cross-fire technic should be used. Within a month after treatment is begun, lime salts seem to be deposited in the tumor until it is converted into bone.

In *lupus vulgaris* it has some curative effect. *Lupus erythematosus* is not benefited. *Eczema* is reported as yielding to this treatment, but to about the same degree that it yields to other treatments. *Acne vulgaris* has possibly been benefited by the treatment. In *acne indurata* the rays seem very beneficial. It is used in *tinea tonsurans*, *erythema induratum*, and *prurigo*. *Pruritus* is said to be helped, but the danger of damaging the

patient's procreative power, if near the genitals, is not inconsiderable; and the most fortunate results are no better than those secured by other methods. The same may be said of the treatment of *psoriasis*. *Mycosis fungoides* is much benefited by *x*-rays. In *tuberculosis of the skin, rhinoscleroma, erythema induratum,* and *sarcoma cutis,* the *x*-rays are helpful. The *keloid of acne* yields to *x*-rays, but *wound keloid* is less amenable. It may be tried for a few exposures in the latter.

The intensive treatment of skin diseases is most effective. Keloid requires 4 to 6 units, tinea tonsurans 4 or 5 units, and eczema and psoriasis 2 or 3 units. The method of divided dosage is best in diseases requiring stimulation such as eczema and psoriasis.

In *rhinoscleroma* the *x*-ray is almost a specific when used intensively from the hard tube.

In *epithelioma* of the skin the *x*-rays have a positive curative effect. It is true that early and superficial epithelioma may be cured by these means with but little scar remaining. Deep ulcerating epithelioma is much less amenable to treatment; rarely the rays may be used in epithelioma so situated as not to be easily accessible for extirpation. Much harm has been done in these cases by *x*-ray temporizing when a radical excision with the knife would have saved the life of the patient. The fear of scar should never be a factor in dealing with cancer in any form; the fear of death should be the more dominant impulse.

In *carcinoma and sarcoma of the deeper parts of the body* the *x*-rays are of value only in the hands of experts who know how to secure penetration without superficial damage. In *epithelioma of mucous membranes* the treatment has little or nothing to offer. The treatment of *recurrent cancer* with *x*-rays has often been followed by subsidence of enlarged glands and other evidences of recurrence, but it has always been difficult in these cases to determine how much effect the rays have had and whether the swellings were really malignant.

This much we know of cancer, that, the more thorough and the earlier the excision of the primary growth, the better the chance for cure. Complete removal of the growth means absolute cure. In the face of this positive knowledge, the uncertainties of the *x*-ray have little to recommend them. As a preliminary treatment to operation and as a secondary treatment which can not be checked up in their results the *x*-rays are of doubtful utility.

In *pseudoleukemia*, the application of *x*-rays to the swellings has given some encouraging results. Likewise some cases of *splenic leukemia* seem to have been benefited.

In *tuberculosis* some recent observers claim good results. Tuberculosis of bones and joints has been treated by three or four exposures at short intervals, the rays being applied intensely from different directions each time. About three exposures from each direction are made. Each area is exposed every three or four weeks. By passing the rays through an aluminum plate, 1 mm. thick, the damaging effect on the skin is inhibited and the deeper effect of the rays increased. The joint should be immobilized and receive the other approved treatments of tuberculosis at the same time. Children should not be given this treatment because of the inevitable effect of the *x*-ray in checking *epiphyseal growth* of the bones.

Tuberculosis of the superficial parts seems to yield to the rays.

Tuberculous of the larynx has been treated with apparent success. In tuberculosus glands of the neck, the *x*-ray treatment has given most gratifying results.

The treatment of *indolent ulcers* by the *x*-rays has given good results, but no better than are secured by the older methods of treatment. Other ulcers have been little or not improved by the rays.

Conclusions.—The *x*-rays are useful in surgical treatment (1) in small dosage to stimulate cellular activity, (2) in moderate dosage to check cellular activity and in (3) strong dosage to destroy tissue. The regulation of these intensities requires the knowledge and experience of an expert radiologist. The diseases in which the *x*-rays have been found useful fall within one or the other of the above classifications.

1. Benefited by stimulation are eczema, tuberculosis, lupus, psoriasis, pruritus, neuritis and neuralgia.

2. Benefited by checking cellular activity are carcinoma, ringworm, hypertrophied thyroid, hypertrophied prostate, myoma of uterus, acromegaly, rodent ulcer and hyperidrosis.

3. Benefited by destruction of tissue are superficial cancer, nevus, warts and rodent ulcer.

Thermoradiotherapy depends upon the principle that the effects of electroradiation upon the tissues are increased as the temperature of the tissues is raised, and decreased as the temperature of the tissues is lowered. In other words the radiosensitiveness of living tissues depends upon their temperature. This principle is applied by heating the tissues which it is desired to affect, and cooling the tissues which it is desired to protect, while the electroradiations are being employed.

In tumors with abundant blood supply, such as sarcomata, normal salt solution is injected into the tumor at a temperature of 50°C. (122°F.). In the case of cancers in the natural cavities of the body such as the rectum and vagina irrigations with saline solution at a temperature of 48°C. (118°F.) are used. In hard tumors which can be heated with difficulty by either of the above methods, high-frequency electric currents are applied by needles thrust into the tumor or by electrodes placed on the surface. Fulguration serves the purpose of heating the tumor. An effective method is to remove the cancer with the knife, fulgurate the wound, and then apply the *x*-ray to the tissues.

It is obviously unwise to place an electrode on the skin in this treatment because of the increased damage it would suffer. The principle of De Keating-Hart now comes into play; the skin is cooled by mechanical means during the treatment. The skin may be covered with a layer of cracked ice confined in a flat bag, or the skin may be moistened and cooled by blowing its surface with a bellows.

The *x*-rays are applied while the tissues are heated. The heating of the tumor, the cooling of the tissues to be protected, and the application of the *x*-rays should all be simultaneous. The longer the exposures, and the more frequently they are applied, the more pronounced the results. Care should be taken lest serious constitutional intoxication take place from absorption of the catalytic products from the tumor. For this reason as much of the cancer as possible should be removed by operation before this treatment is applied.

The advantage of this method is that a more rapid destruction of the cancerous tissue is accomplished with a smaller dose of the rays than by the ordinary methods of applying the rays. (For details of the technic of *x*-ray therapy the reader is referred to the special works on that subject, such as "Medical Electricity, Röntgen Rays and Radium," by Sinclair Tousey, W. B. Saunders Company.)

HELIOTHERAPY

Light-rays directly from the sun have a decided stimulating and healing effect upon ulcerating surfaces. Old **ulcers of the leg,** it has long been known, are decidedly benefited by this treatment. The patient is placed so that the light of the sun falls directly upon the ulcer which is left without any covering. As the patient sits with his foot elevated in a comfortable position in the fresh air during the sunny part of the day, it is possible that other influences play a part in effecting the cure.

Some surgeons expose the ulcer to the sun for only half an hour each day, or make several short exposures at intervals during the day. My own experience shows that the benefits of the treatment may as well be enjoyed for several hours daily, the shorter intervals of half an hour being used when the sunshine is very warm. To avoid sunburn dermatitis is the only precaution that is necessary.

Finsen, of Copenhagen, showed that the actinic rays of the sun have a positive germicidal effect. By concentrating these rays by means of lenses, powerful action may be secured. The chemical rays may be separated by prisms. The interposition of colored glass is also used to filter out other sorts of light. Finsen used also the actinic rays from the electric light. The best results were secured in the treatment of tuberculosis of the skin. *Lupus* is amenable to cure by this treatment, but to be effective many treatments must be given for weeks and sometimes for months.

Granulating surfaces do remarkably well under sun treatment. Chronic cellular infiltration, following acute infection, clears up in the sunlight.

Sunlight is not only of use in ulcerated surfaces but many other morbid conditions are benefited by it. **Tuberculosis** without ulceration may be exposed to the sun with benefit; indeed, it may be said that tuberculosis is a disease that thrives best in darkness. It is well known that the rays of the sun quickly kill the tubercle bacillus.

Heliotherapy in surgical tuberculosis has been worked out by A. Rollier of Leysin, Switzerland ("Die Heliotherapy der Tuberculose," by A. Rollier, Ausgab. Julius Springer, Berlin). All of the body but the tuberculous part is gradually subjected to a sun-tanning process, then the tuberculous part, and after that the whole body is exposed to the sun and the weather until a deep pigmentation is secured.

At the first treatments the patient is protected from wind, the head is covered with a thin cap, and the eyes are protected by colored glasses. The patient's feet are exposed to the direct rays of the sun 3 or 4 times daily for five or ten minutes at hourly intervals. On the second day the feet are exposed to the sun ten minutes and the legs from the ankles to the knees 3 or 4 times for five minutes at hourly intervals. On the third day the feet are exposed fifteen minutes, the legs ten minutes, and the thighs five minutes, 3 or 4 times at hourly intervals. On the fourth day the exposure of the feet, legs, and thighs is increased by five minutes at hourly intervals 3 or 4 times. On the fifth day, the exposure of the feet, legs, and thighs is again made five minutes longer and the abdomen and lower chest are exposed five minutes 3 or 4 times in the day at hourly intervals. On the sixth day the exposure of all the previously exposed parts is again increased five minutes, and the upper chest, the head, and neck are exposed five minutes 3 or 4 times at hourly intervals. All of these treatments are given to the front of the body. If the patient is doing well he is turned over and the same treatment given to the posterior parts as he lies face downward.

While these exposures are made the diseased region is kept covered and protected from the sun. When the whole body has been gone over as above described, the diseased region is last exposed. About two weeks of exposure are required before the disease is reached.

After this the length of exposures are gradually increased. As the tanning progresses the whole body is exposed at a time. After each exposure the patient is rubbed with spirits of camphor with a rough glove. Finally the exposures to the sun's rays amount to four or six hours a day.

This treatment is carried out with the patient in bed. By this graduated method and with watchfulness, sunburn does not occur. On cloudy days the body is exposed to an air bath to keep the reaction of the skin stimulated. As the patient improves and as soon as conditions will allow he is permitted to go about. As the body becomes tanned the patient goes about in the sun unclothed for a longer period each day. Finally in summer the patient should be naked in the sun most of the day. Children play about naked in the sun all day.

Following the primary coat of tan the skin becomes bronzed, and finally a chocolate hue appears, which indicates the desired degree of intense pigmentation. This process is accompanied by an increase of hemoglobin and red cells in the blood. There is a pronounced increase in the number of lymphocytes. In cases in which there are open lesions with complicating infection or abscess, the leukocytosis gradually falls to normal. There is a pronounced tendency in these cases to improvement of the general health and of the local tuberculosis.

Immobilization or whatever other protective treatment of the local disease is indicated, according to the general principles of surgical treatment of tuberculosis, should be applied. This need not interfere with the heliotherapeutic exposures. Plaster-of-Paris can not be used, but apparatus for immobilizing can easily be constructed which does not shut out much of the sun's rays. Wherever there are open lesions, such as sinuses or ulcers, dressings should be left off during treatment and the direct effect of the sun applied. The dressings may be applied when the part is not being exposed to the sun. The most satisfactory results have been secured in the treatment of tuberculous lesions in children.

These children under the care of Rollier go about naked in the snow during the winter months, after they have developed the requisite amount of resistance. Experience has shown that children treated with their clothes on develop colds during the winter while the naked children under the same conditions do not have colds.

Tuberculous spondylitis, adenitis of the neck, tuberculosis of joints and bones, tuberculous peritonitis, renal and genital tuberculosis have all yielded good results in this treatment.

Rollier (Corresp. Blatt. für Schweizer Aerzte, Dec. 19, 1914) reported to the Swiss Surgical Association his results in 2000 cases of tuberculosis of bones and joints treated during the past ten years. He has discarded plaster cases entirely, and uses only extension to relieve pressure and facilitate the development of muscles. In disease of the spine the direct exposure of the back to the sunlight has seen abscesses heal without opening, and a minimum of deformity follow healing. Among 158 cases of hip-joint disease, 125 were completely cured with restoration of function in 102. Among 120 knee cases, 106 were cured, with restored function in 78. Among the 198 cases of spondylitis, 171 were cured, and 18 improved. The patients are given work out of doors as soon as they are able to do it.

RADIUM

Radium is a substance which emits radiations much like the *x*-rays. Other similar substances are barium, uranium, mesothorium and polonium. The term *radiotherapy* is applied to all of them. Radium is the most powerful. Its effects on surgical diseases is much the same as the *x*-ray. Its dosage can be controlled better than that of the *x*-rays. Radium emits three well-recognized rays: the α-rays, the β-rays, and the γ-rays. The α-rays are the heat rays; they burn the skin; they have but slight penetrating power; and are almost entirely stopped by a sheet of mica, glass, lead, or even cardboard. The β-rays have a velocity about the same as that of light; they have a penetrating power 100 times as great as the *x*-rays; and are almost all stopped by a plate of lead 3 mm. thick. The γ-rays have a penetrating power 10,000 times that of the α-rays. The γ-rays emitted by 30 mg. of radium bromid are capable of penetrating a steel plate 30 cm. (1 foot) thick. Only the γ-rays are desired for therapeutic purposes. There is no discovered difference in the qualitative action clinically between *x*-rays, radium, and mesothorium. The γ-rays of radium are about 40 times itronger than the hardest *x*-rays.

Fig. 2208.—Radium Applicator.

The radium is used in the form of its salts: the bromid, sulphate, chlorid or carbonate. As the action of the α- and β-rays is superficial they are eliminated and the penetrating γ-rays employed. This is accomplished by enclosing the radium in a metallic capsule. A thickness of 2 or 3 mm. is used. This allows the transmission only of γ-rays and the harder β-rays. The secondary rays which develop in the filter are eliminated by surrounding the metal with a covering of five or ten thicknesses of black paper, enclosed in pure elastic rubber.

Other metals besides lead are used as filters. Gold (0.6 to 0.8 mm.), platinum (0.5 mm.), silver (2 to 3 mm.), and brass (1 to 1.5 mm.) have about the same filtering power as lead (2 to 3 mm.). Lead has been found to be associated with irritating secondary rays which are not present with the other metals. Screens of aluminum and silver are more to be recommended.

Radium is used contained in a capsule of the desired coverings. It is also enclosed in a capillary tube which may be inserted in a hollow needle, which may be used to penetrate the tissues. *Radium emanation*, a gaseous form of radium salts, is also used in a container. A thin platinum tube is used to contain 100 mg. of pure radium chlorid in a glass container. The platinum is 0.4 mm. thick. The whole tube is covered by a rubber cot 3 mm. thick (Fig. 2208).

The **dose of radium,** to a limited extent, can be regulated and measured. It is measured in milligram hours, which are the number of milligrams of radium multiplied by the number of hours of exposure. A compact mass of radium or mesothorium emits a more powerful and concentrated effect than the same mass spread out over a larger area. A greater effect is secured with a larger amount of radium for a shorter time of exposure than by a number of longer exposures with a smaller amount. The effect of 5000 mg.-hours obtained from 50 mg. of radium, is quite different from that obtained

from 5 mg. of radium, the former being used for 100 hours and latter for 1000 hours. The effect of small doses is to stimulate growth and cause hypertrophy; while large doses cause death of cells and atrophy. Small doses of radium have the power of stimulating the growth of cancer. This is the case with the *x*-rays also, in which soft rays in small amount make the patient worse. It is possible for too large a dose of radium to cause the destruction of neighboring organs, produce sinuses of hollow viscera, and induce fatal sepsis from the absorption of much necrotic tissue or other toxic products.

It is best to use 50 to 100 mg. of radium elements in one mass. It is probable that less than 50 mg. of the element may in some cases do more harm than good. This should not be confused with radium salts. Ten milligrams of the radium elements are equal to about 17 mg. of radium bromid, 13 mg. of radium chlorid, 14 mg. of radium sulphate, or 13 mg. of radium carbonate. Writers should specify their potencies accordingly. The radium should be enclosed in a metal filter to exclude the α- and soft β-rays. A rubber cover over the metal capsule must be used to absorb the secondary rays.

The effect of γ-rays on cancer tissue is an intensification of *x*-ray action. Hyperemia occurs during the first three weeks. This is followed by cessation of division of cell nuclei, breaking down of the nuclei and protoplasm, and destruction of the cells. This is accompanied by the deposit of an increased amount of new connective tissue. Later this connective tissue becomes hardened and then undergoes hyaline degeneration. Blood-vessels become obliterated by proliferation of the intima. In superficial epithelioma improvement should be noticed after two or three daily treatments. By the end of four weeks improvement should be evident to gross examination in cancer of the uterus. In some cases at the end of four weeks no effect seems evident, but two weeks later the cancer may have disappeared.

It is probable that the rays do not destroy cancer farther than 3 or 3.5 cm. (1 or 1½ inches) distant from the radium. As carcinoma is usually not thicker than 1 or 2 cm. (½ or ¾ inch), and if it is thicker than 2.5 cm. (1 inch) it is usually inoperable, the value of radium rays is apparent. Metastases and deeper growths which sometimes disappear may have been cured in these cases by the action of antibodies liberated by the treatment. There are very tangible evidences that radium and the *x*-rays liberate from cancer or cause the development of antibodies which have a healing effect on cancerous disease not immediately reached by the radiations.

Some surgeons supplement the radium treatment with *x*-rays in large doses to reach distant deposits. Some use intravenous injections of borcholin or colloid metals to augment the action of the rays. Radium is used by many surgeons after cutting operations, to prevent recurrence. Apparently inoperable cancer of the uterus has been rendered operable by the radium treatment. In operable cases the radium naturally gives the best results.

There is a general belief that radium, like the *x*-rays, should not be used in place of operative excision of cancer, if it is operable, but that it should be reserved for inoperable cases and as a continuation treatment after operation. There is a growing tendency among surgeons to subject their operative wounds to radium and the *x*-rays.

The amount of milligram-hours of treatment employed varies from 2000 to 6000 or more.

In **inoperable epithelioma of the face,** daily treatments may be given with 50 mg. to 100 mg. of radium element divided in three or four tubes, all placed at different locations on the surface of the disease, and left for half an hour. A dosage of 1200 mg.-hours in ten applications daily or every second day, with an average of 75 mg. of radium should give decided results,

The intervals may be lengthened as improvement appears. Inflammatory reaction calls for temporary discontinuance of treatment.

In **carcinoma** of the **uterus** and **vagina** a 50-mg. radium tube, or stronger, is placed against the growth and held there by a pad covered with lead foil to protect the other tissues. This should be done after operative removal has been carried on as far as possible. Excellent results have been reported with treatments of 3000 mg.-hours.

There is a tendency to increase the initial dosage, and begin with more intensive treatment. The first treatment should be given in a single dose—100 mg. Then there should be a pause of five or six weeks before a second treatment is given. Examination should be made once a week. Usually it will be observed that the cancer begins to diminish in about two weeks, and continues to diminish for five or six weeks. If the growth seems to have disappeared at the end of six weeks, another four weeks should elapse before another treatment is given. Even though a cure seems to have been secured, treatment should be given every few months for one or two years.

When smaller dosage (50 mg.) is used, the treatment may be given more frequently. One application may last ten to twenty-four hours. The intervals between treatments may be from seventy-two to ninety-six hours. Improvement is usually observed after the dosage has amounted to 3000 or 4000 mg.-hours. After that the treatments are given weekly, and then every two weeks. A total dosage of 8000 to 10,000 mg.-hours are required.

The intensive treatment is most useful, and 3000 to 4000 mg.-hours may be applied within from 6 to 8 consecutive hours.

The interval method consists in six to eight treatments with an interval of from thirty-six to sixty hours. This is followed by three weeks of intermission. If there is an apparent cure, two or three more applications of 500 or 600 mg.-hours should be given every second or third day. After another three weeks have passed, if examination shows no disease, cure may be considered possible. If disease is still found 3000 or 4000 mg.-hours should be given. This interval method applies about 3000 to 4000 mg.-hours of radium element within two to three weeks. The α- and β- rays may be stopped by a brass covering 1 or 1.5 mm. thick. The rubber covering to remove secondary rays should be about 1 to 3 mm. thick.

The present status of treatment in uterine cancer calls for operation in operable cases. After operation the prophylactic use of radium is recommended. About the tenth day after operation radiation is begun, and continued at four-week intervals. Ten hour treatments with 50 mg. of radium are given.

In inoperable cases, as much of the growth as possible is removed. Then after two or three days, five exposures of twelve hours each are made, the intervals between the treatments being from twelve hours to several days. After intervals of three or four weeks, a second or third series of treatments are given.

In the inoperable cases many radiotherapeutists combine radium and x-ray treatment. In a typical case of epithelioma of the vagina the patient receives eight applications of radium of twelve hours' duration with an interval of thirty-six hours between each treatment, 50 mg. being used. The tube is screened with 0.5 mm. of silver, 0.75 mm. of gold, and several layers of black paper, and the whole enclosed in a rubber tube. At the same time x-ray treatment is given in massive doses. Ten x-ray treatments are given with the Gauss water-cooled tube. The rays are filtered with 3 mm. of aluminum and 2 mm. of chamois skin. The rays are sent through four fields in the abdomen and two fields in the back. The combined quantity should equal

480 X. This gives an idea of the combination of these two methods of treatment (Figs. 2209 and 2210).

The radium treatment of *fibroid tumor*, **myoma of the uterus,** gives most gratifying results. The cervix is dilated, and from 30 to 750 mg. of radium introduced into the interior of the uterus. In large tumors additional treatment may be given through the abdominal wall. The radium is screened with platinum and rubber. Subperitoneal and even pedunculated tumors respond to this treatment as well as interstitial and submucous growths. A satisfactory dosage is 1 Gm. of radium element per hour. The hemorrhage stops and the tumor decreases or disappears in most cases.

In **epithelioma of the tongue** a radium tube is buried in the tumor. But poor results have been obtained in **carcinoma of the rectum.** This method has been to make daily exposures of six hours each for five days with 100 mg. of radium. This 3000 mg.-hours treatment is repeated every six weeks.

FIG. 2209.—METHOD OF APPLYING RADIUM TO THE CERVIX AND VAGINA.

The radium is enclosed in a lead cylinder 2 mm. thick. The cylinder is enveloped in a rubber glove finger. A wire should be attached to the cylinder, which should project from the anus and be fixed by adhesive plaster.

In **cancer of the esophagus** and **stomach** radium has been successfully used. Such tumors have been radiated by a tube enclosed in a catheter.

In **carcinoma of the prostate** 50 to 100 mg. are used. In **carcinoma of the bladder** 50 mg. are used. Hopeful results are reported in the radium treatment of cancer of the prostate and bladder. The tumors of the bladder which respond to fulguration are the benign papillomata. Papillary carcinoma may actually be stimulated in its growth by fulguration and radium; the best treatment is resection of the bladder. Radium will destroy both the malignant and the benign papilloma. Fulguration after radium treatment seems to be a most effective combination. If after using radium, or if after

three or four treatments with fulguration, the tumor is not made much smaller, resection should be done.

In **carcinoma of the breast** radium tubes should be buried in the growth. From 4000 to 6000 mg.-hours of treatment should be given.

In **sarcoma** some striking cures have been reported. Radium tubes are buried in the tumor through small incisions.

In **exophthalmic goiter** smaller doses seem effective. *Bleeding in myomatous uterus* is favorably influenced by 3000 mg.-hours of radium. *Warts* are promptly cured by short exposures—twenty to sixty minutes. **Keloids** react most favorably to radium. **Lupus erythematosus, psoriasis, chronic eczema,** and **pruritus** seem amenable to radium treatment.

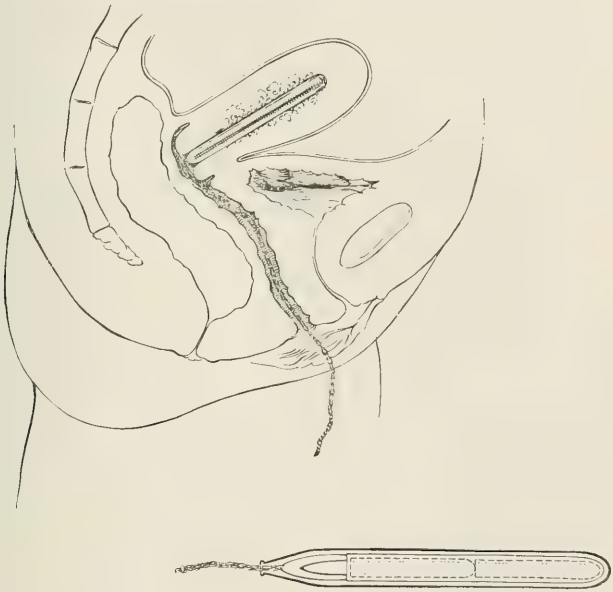


FIG. 2210.—RADIUM INSERTED IN UTERUS.

In dermatological treatment several forms of applicators are used. A popular form is a rectangular linen pad with an area of 12 sq. cm. and having one-twentieth strength. Other applicators have metal backs and are one-fourth and one-half strength. These applicators are constructed so that 10 mg. of radium salt are spread out over 1 sq. cm. of surface. The one-twentieth strength applicator contains 0.5 mg.; the one-fourth strength contains 2.5 mg.; the one-half strength contains 5 mg.; and full strength is 10 mg. to the square centimeter of surface.

Localized **pruritus** often yields to radium. External **pruritus ani** may be treated with unscreened varnished tubes used for five or ten minutes, re-

peated several times. If the disease is within the anus 25 to 50 mg. element may be used in a 0.5 mm. silver screen in three or four exposures of fifteen minutes each.

In treating **lupus erythematosus,** radium screened through 0.1 mm. of silver, is perhaps best, in one-fourth or one-half strength. Each patch is treated for from four to six hours during a period of two weeks.

In **angioma** (vascular nevus, port-wine stain, birth-mark), the results are more satisfactory than with any other treatment. In the superficial diseases just enough radiation should be applied to cause erythema and desquamation. The desired result can be secured with a one-twentieth strength applicator, screened with 0.01 mm. of aluminum, after four or five hours of treatment. Several applications may be depended upon to give decolorization of the pigmented area. One-fourth strength unscreened applicators should be used for elevated papillomatous angiomata; from two to four hours of treatment in divided doses are given. Exposures of fifteen or twenty minutes are made.

In **nevus** of the scalp and face small doses seem to suffice—120 mg.-hours are enough in infants. By compressing the growth to remove the blood the action of radium is more effective.

In **keratosis of the hand, due to** *x*-**rays,** radium has been found useful. The thickened skin should be pared down with a knife as thin as possible. Twenty milligrams of radium element are enclosed in a small glass tube, covered with thin, soft rubber, and placed on the protective metal which lies upon the diseased patch.

The application is made for thirty minutes, the tube being held in place with rubber adhesive. One treatment usually suffices. The diseased skin exfoliates in about a month.

In **sycosis vulgaris**, long-standing cases, which have resisted other methods, may be treated by removing the hair with radium. **Lichenification** of the skin yields to radium.

In the treatment of **keloid** it is customary to use one-quarter strength radium applicator screened with 0.1 mm. of lead, or not screened at all in older cases. Covering a period of a week, a total of six hours of treatment in doses of one hour each may be given. If unscreened dosage is used in one-quarter strength, treatments of twenty minutes each are given every other day.

Massive dosage has come into use more recently, especially in treating **cancer in the pelvis.** As much as 800 mg. of radium and mesothorium, separately and in combination with *x*-rays, are used. Tubes of such dosage have been left in the tissues as long as eight days. This is the so-called "intensive gamma therapy."

Usually treatment begins with the β-rays, a thin filter being used. The rays are applied very closely to the disease, while healthy tissue is protected with lead. After ten days larger doses and a lead filter are employed. The large dose averages 150 to 300 mg.

Radium and its allied metals are still so new in surgery that further experimentation is needed. Out of the large amount of material that is now accumulating definite conclusions will be reached. A bibliography of the subject is found in Keene's Surgery, vol. vi, page 1179; and in Surgery, Gynecology and Obstetrics, vol. xx, No. 1, January, 1915—International Abstract of Surgery, page 8.

The internal use of radium opens a field of limitless possibilities. A standard radium solution for drinking is made of 2 micrograms of radium

chlorid in 60 c.c. of distilled water, which amount is taken 2 or 3 times daily. The treatment is continued for six weeks, or until reaction occurs

A standard solution for intravenous injections contains 50 to 100 micrograms in 2 c.c. of salt solution. The largest doses are 100 to 300 micrograms. The injections are with a glass syringe in the cephalic vein. One to three doses may be given at intervals of ten days.

The intravenous injection of radium chlorid has the same effect as radium emanation, and produces a lasting radioactivity in the body, becoming fixed mainly in the bone marrow. It increases the number of red blood cells, causes slight leukocytosis, increases secretion of urine, and stimulates purin-body metabolism. It is used in anemia, arthritis deformans, polyarthritis, high blood-pressure and neuralgias.

A **radium compress,** 18 by 25 cm. (7 by 10 inches), containing 30 micrograms of radium, is used locally to allay the pain in acute joint diseases, chronic arthritis and gout. A compress, containing 16 micrograms, is used in sciatica, bursitis, sprains, myositis, and neuritis. Many other sizes and shapes are used, the radium content varying from 4 to 30 micrograms.

VIBRATORY MASSAGE

Electrical engines, which are adjusted to produce rapid vibrations by means of an electromagnet or oscillating mechanism, are useful for applying massage. The massage is produced by a rapid series of light blows. The hammer which is applied to the body is moved about over the affected area and acts similarly to massage or the electric current itself. The circulation is stimulated; the movements of lymph are increased; the blood-vessels are caused to dilate; absorption is promoted; and the local metabolism stimulated. This treatment is useful where there are products of chronic inflammation to be absorbed. It hastens the removal of cellular deposits and the stretching and melting away of cicatricial tissue. It has a distinct place in surgery.

INJURIES FROM ELECTRIC CURRENTS, RADIATION AND GAS POISONING

ELECTRIC SHOCK

Alternating electric currents of small quantity (ampèrage) are not harmful to the human body even though they are currents of very high tension (voltage). Nor are currents of large quantity (ampèrage) harmful provided the tension (voltage) is low. High voltage combined with large ampèrage makes the current dangerous. The currents used by municipal lighting and power plants for driving street railway cars are highly dangerous as their voltage ranges from 200 to 1000, with correspondingly high ampèrage. Some currents range as high as 10,000 volts. Currents of low voltage (100 volts) are not apt to produce serious effects.

When a part of a person's body is in contact with a metallic tool which causes a short circuit, the tool may be melted and the person burned and shocked. When a strong current of high tension passes through the body the muscles are thrown into a state of spasmodic contraction. If the hands or other parts which may embrace an electrified object are caused to contract by such a current, the person may not be able to free himself, and may remain in contact with the current until the relaxation of death releases the contact. Cardiac fibrillation and respiratory paralysis are the causes of death. The effect upon the heart is less pronounced as the tension of the current becomes higher, but the effect on the central nervous system is increased. With higher tension currents respiratory failure comes first.

To rescue a person from such a situation requires some knowledge of electricity. If possible the current should be shut off. A live wire may be cut with an ax or properly insulated pliers. If this can not be done the person should be pulled away from the conductor. If the victim is clutching the conductor and cannot relax his grasp and the current is passing through his body to the ground, it may be best to lift him from the ground, and thus discontinue the current. The rescuer should remember that the current is passing through the body and to touch it may mean death to him also unless he can properly insulate himself. By using a pole, or rope, or by covering the hands with woolen, wool-lined, or rubber gloves, or with a coat or other wool or silk material, or a mass of cloth or waste, the current may be insulated against passing to the rescuer, if he has to touch the victim's bare body. He should not stand in water or other wet place but should throw a coat or other woolen garment on the ground and stand on that. The rescuer should be careful not to touch any metal part such as buttons, or the region of the waist or pockets where keys, knife, or other metal objects may be. Usually all the protection the rescuer needs is the clothing of the victim, which he should grasp and quickly pull him away from the conductor. Nothing that is wet should be touched. Only one hand should be used if possible. The removal of the person from the electric contact should be done as quickly as possible.

The effect of strong currents upon the heart may be permanent and resuscitation impossible. Often the heart and respiration are not permanently paralyzed. Usually the shock is not immediately fatal, but the person is only stunned and only breathing is paralyzed.

If the victim is breathing and the heart is acting, he should be laid in a comfortable position, the clothing should be loosened, he should be kept warm, and given plenty of fresh air.

Artificial Respiration.—If the patient is not breathing, quick action is necessary. Respiratory paralysis is the thing to be combatted. Time should

FIG. 2211.—ARTIFICIAL RESPIRATION BY THE METHOD OF SCHÄFER.
Inspiratory period.

not be wasted in speculations as to whether he is dead or not. It should be assumed that he is not. Every moment counts. The finger should be passed in his mouth to remove any foreign body such as tobacco, chewing gum or false teeth. He should be rolled over on his abdomen, the head turned to one side so that it rests on the cheek, the arms extended straight above the

FIG. 2212.—ARTIFICIAL RESPIRATION BY THE METHOD OF SCHÄFER.
Expiratory period.

head, and artificial respiration begun. An assistant should draw out the tongue and see that the nose and mouth are not obstructed.

The rescuer should kneel astride of the victim, facing his head, and spread out the palms of his hands over the lower part of the chest and loins, one on each side (Fig. 2211). He keeps his arms straight and allows his body to fall forward so that his weight presses his palms firmly against the body of the victim (Fig. 2212). This pressure falls upon the most elastic part of the

chest and the region of the diaphragm and causes the air to be expelled from the lungs. He at once swings back, releases the pressure, and the natural elasticity of the ribs and lungs causes the chest to expand, the diaphragm to descend, and air is inspired into the lungs. This is *Schäffer's method* or the *prone method of artificial respiration.*

This operation should be repeated with regularity, to imitate the natural rhythm of respiration. Each act should be done about every four seconds, with an interval of two seconds allowed for relaxation and expansion of the chest. There should be about sixteen or eighteen of these compressions per minute. Normal respiration is about sixteen to eighteen per minute. If there is no clock or watch handy, the operator may be guided by the respiration of a bystander, or by his own which is apt to be somewhat faster than normal. The resumption of voluntary respiration should be watched for,

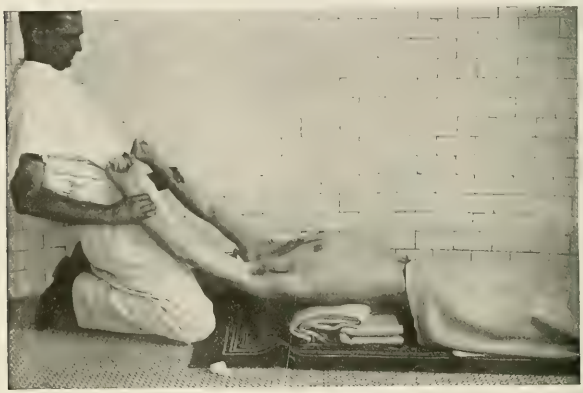


FIG. 2212*a*.—SYLVESTER METHOD OF ARTIFICIAL RESPIRATION. INSPIRATION. (*From J. C. DaCosta's Modern Surgery.*)

A pad is placed under the shoulders. The tongue is drawn forward. The operator kneels at the head of the patient, grasps the forearms, circumducts the arms outward and upward, and makes traction when the arms reach the highest position above the head. This traction lifts up the ribs, expands the chest, and causes inspiration.

and when it appears the artificial respiration should be made synchronous with it.

Artificial respiration should thus be continued for one or two hours or until there are positive evidences of death. People have been resuscitated after two hours of respiratory failure. The case of a workman is reported by Thomas Oliver (London Lancet, Feb. 11, 1911) who received a current of 2000 volts and was declared dead by a physician; but his fellow workers proceeded with artificial respiration and after an hour's work were rewarded by restoring the respiration, and the man made a complete recovery.

Howard's method places the patient in the same position as the Sylvester method with a roll behind the back and the arms above the head. The operator kneels astride of the patient, spreads out his palms over the lower part of the patient's chest on either side, and makes strong pressure by throwing the weight of his body forward.

Sylvester's method places the patient as above described. The operator kneels above, and rythmically extends the arms above the head and presses them against the sides of the body at the rate of sixteen times a minute (Figs. 2212*a* and 2212*b*) (see also Vol. I, page 98).

Instruments for producing artificial respiration are discussed on page 728. Such apparatus consists of a hand pump connected with a face mask whereby air may be pumped rhythmically into the lungs. Some such apparatus is provided with oxygen tanks. It may fail unless the tongue is drawn out. These machines should never be permitted to cause delay in the application of simple manual measures for artificial respiration.

A more effective expedient than any other in cases of respiratory paralysis, which does not respond to artificial respiration, is intratracheal insufflation (see Vol. II, page 446). This may be done with a catheter and a bellows, or other pump.

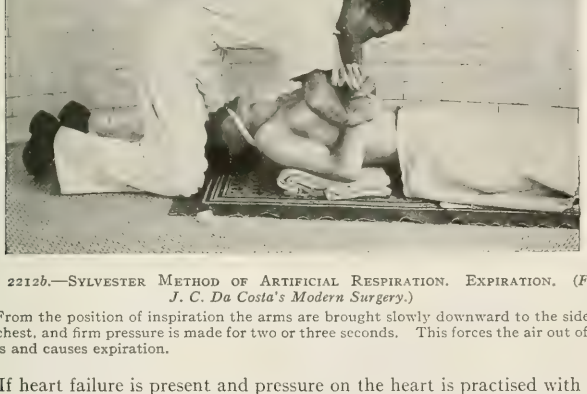


FIG. 2212*b*.—SYLVESTER METHOD OF ARTIFICIAL RESPIRATION. EXPIRATION. (*From J. C. Da Costa's Modern Surgery.*)

From the position of inspiration the arms are brought slowly downward to the sides of the chest, and firm pressure is made for two or three seconds. This forces the air out of the lungs and causes expiration.

If heart failure is present and pressure on the heart is practised with the victim lying on his back, artificial respiration may be applied at the same time by another person by means of alternating traction upward of the arms and pressure on the chest (see Artificial Respiration, Vol. I, page 98; Vol. II, page 446; Vol. III, page 728).

An assistant may at the same time grasp the tongue and draw it forward and push it back rhythmically with the respiratory movements, to open the glottis by traction when the pressure on the chest is relieved, and to allow it to close when pressure is made on the chest. This may be repeated for a few times but need not be done continuously.

If the heart has stopped, artificial respiration is apt to be of little use. For this reason, if there are distinct signs of heart paralysis the victim should be placed on his back with a roll behind the shoulders to throw the chest forward. In this position strong pressure on the left chest and on the abdomen under the ribs should be made to compress the heart. This should be done at the rate of 60 times a minute. Pressure should not be made on the stomach lest food be forced up and enter the larynx.

It is doubtful if any medication is of service, with the possible exception of inhalation of ammonia or other respiratory irritant, and the injection of a diffusible stimulant such as camphor or ether. Forcible stretching of the sphincter of the rectum may be of value in stimulating respiration. Massage of the extremities toward the trunk and hot applications are indicated, and should be attended to by an assistant.

By artificial respiration the patient may be kept alive until the depressed central nervous system recovers itself. This is most important.

As the commercial high tension currents are alternating currents of large amperage, they produce death by paralyzing the respiratory centers of the brain. Robinovitch (Jour. Am. Med. Assoc., July 18, 1911) recommended the application of a direct current, interrupted 6000 or 8000 times per minute, applied to the chest so that it may traverse the heart. This may be combined with artificial respiration.

If there has been no heart action or no respiration for a period of eight or ten minutes the chances of recovery are poor. In such cases, circulation and respiration may be reëstablished, but because of the damage to the nutrition of the brain which has occurred in this period, consciousness is not regained. In the cases in which recovery has taken place after long periods of presumed heart and respiratory paralysis, it is probable that the paralysis of these functions was not complete but that there was present slight cardiac action and shallow respiration which were not discovered.

ELECTRIC BURNS

X-ray Burns.—It should be borne in mind that the rays do not affect the epidermis so much as the underlying structures, the walls of the vessels being especially damaged. When the burns are limited to a *dermatitis* the most important thing is to discontinue exposure to the rays. After this the most important curative agents are the natural forces of bodily repair. Time may be expected to heal the dermatitis. The circulation may be improved and metabolism stimulated by the use of heat.

When the skin has broken down as a result of the lack of nourishment, due to the damage to the vessels, and *x-ray ulceration* has developed, the treatment is the same as for dermatitis. Added to this is the treatment of the ulcer. Many of these ulcers are extremely rebellious to the treatment which usually cures other ulcers, such as cleansing, antiseptic solutions, ointments and iodin. These intractable ulcers are often helped by the application of compound tincture of benzoin.

Painful ulcers which do not yield to ordinary treatment must be dealt with by dividing the sensory nerves. This may be done just beyond the border of the ulcer, the incisions being made across the paths of the nerves. (*Burns from high-power electric currents* are treated the same as burns due to high degrees of heat; see Vol. I, page 820).

GAS POISONING

Asphyxia from illuminating-gas or coal-gas should be treated by bringing the patient into fresh air as soon as possible. If respiration has ceased or is very shallow artificial respiration should be practised (see Artificial Respiration, Vol. I, page 98; Vol. II, page 446; Vol. III, page 728).

If the patient is breathing poorly, artificial respiration should be used. Patients whose respirations were found to be only 2 or 3 times a minute have been saved.

If the patient is breathing and conscious he should be encouraged to take deep breaths. This is very important to get rid of the poisons and bring in as much oxygen as possible.

If he is unconscious, but breathing, a stomach tube should be passed into the stomach and a pint and a half of warm water at 40°C. (104°F.) run into the stomach and siphoned out. This operation should be repeated several times as the operation stimulates respiration and at the same time removes some of the poisonous products which are excreted through the stomach. Then 2 or 3 ounces of castor oil should be left in the stomach with the view of cleansing the bowel.

These gases cause destruction of red blood-cells, and death follows from this cause. For this reason the most effective treatment in serious cases consists in drawing off 250 c.c. to 500 c.c. of blood and transfusing from a blood-relative the same amount of healthy blood. If this is not done, infusion of 1000 c.c. of normal salt solution should be practised, while 250 c.c. of blood is drawn off from a vein. Treatment by infusion was first published by P. M. Pilcher (Brooklyn Med. Jour., vol. xvii, 1903). Thompson (Medical Record, N. Y., vol. lxvi, 1904) reported remarkably good results from the removal of 450 to 550 c.c. (15 to 18 ounces) of blood, and the infusion of 1000 to 1500 c.c. of normal salt solution. Massage of the limbs is useful to keep the blood moving.

The pulmotor and lungmotor apparatuses with an air-tight face mask, which act automatically by suction and compression, drawing out and forcing in air or oxygen, thus emptying and filling the lungs, may be used.

The artificial administration of oxygen by inhalation is to be recommended in all cases. *Intratracheal insufflation*, after the method of Meltzer, is of decided value if breathing has stopped, and should be used if artificial respiration does not promptly restore respiration (Vol. II, page 446).

These patients may seem to be recovering, but after a few days they begin to fail, and die from disintegration of their red blood cells. Of all of the methods of treatment in patients who are breathing none offers as much assurance of success as the introduction of kindred blood by transfusion.

Poisoning from irritating gases, such as chlorin, bromin, ammonia, and vapor of nitrous, hydrochloric, or sulphurous acids, which occurs in industry and more recently as an expression of modern warfare, must be met by removing the victim to the fresh air as promptly as possible. The bronchitis and pulmonary edema which supervene require fresh air for their treatment. Edema of the larynx may be fatal, and for this reason tracheotomy should be performed and a trachea tube inserted upon the first appearance of obstruction.

The so-called "mustard gas" clings to the clothing, which should be removed as soon as possible, and the exposed surfaces of skin washed. The burns which result should be treated by the methods described for treating dermatitis or burns.

Poisoning by irritating gases should be prevented by wearing "gas masks" when exposure is expected. Artificial respiration may be required to resuscitate the victim of gassing.

Sewer-gas poisoning, which is largely due to hydrogen sulphid, ammonium sulphid, and carbon dioxid, is treated the same as illuminating gas poisoning. Usually it is less urgent than the latter. Often it is more a matter of exclusion of oxygen than of actual poisoning. The most important step in the treatment is to bring the victim to the fresh air.

FIRST AID TO THE INJURED

Accidents often occur under circumstances in which confusion and unpreparedness exist. Rapid transportation, the power of machinery, intensive and monotonous application, fatigue, and the high pressure under which modern industry is carried on are capable of producing many casualties. The prophylaxis of accidents will be promoted most effectively when industry is conducted for the purpose of serving the needs of all of the people. (For a further discussion of this subject see: J. P. Warbasse "The Socialization of Medicine," Jour. Am. Med. Assoc., July 18, 1914, and "Conserving Health versus Exploiting Disease," Med. Rev. of Rev., March, 1917; Public Health Bulletin, No. 76, March, 1916, U. S. Treasury Dept.; Bulletin No. 30, Report on National Vitality, by Prof. Irving Fisher; The Child Labor Bulletin, 1914, 1915, 1916, 1917 and 1918, Report of United States Commission on Industrial Relations, 1915; Reports of United States

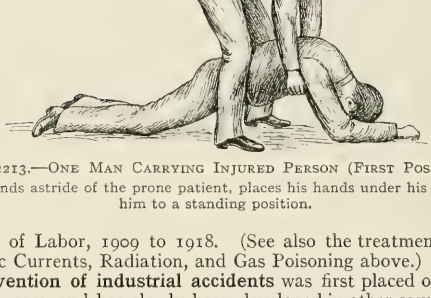


FIG. 2213.—ONE MAN CARRYING INJURED PERSON (FIRST POSITION).
The carrier stands astride of the prone patient, places his hands under his chest, and lifts him to a standing position.

Department of Labor, 1909 to 1918. (See also the treatment of Injuries from Electric Currents, Radiation, and Gas Poisoning above.)

The prevention of industrial accidents was first placed on a scientific basis in Germany, and has slowly been developed in other countries. **Museums of Security,** for exhibiting, teaching, and encouraging methods for preventing accidents, have sprung up in most industrial centres.

Workmen's compensation for injuries has been enacted into laws in many countries, and serves to prevent accidents by making the injury of workmen a cause of reduction of profits.

First aid to the injured has been provided in factories, mines, and other industrial plants. Hospitals and dispensaries have developed in connection with these movements. Surgeons, physicians, and nurses are being provided to care for the injured. Railroads have hospital cars, hospitals, and railroad surgeons.

All of these modern provisions tend to minimize accidents and give better care to the injured.

The surgical treatment of industrial accidents should be upon the same principles as other surgical conditions. The peculiar feature is that the injuries are often complicated; and treatment for fractures, wounds, hemorrhage, burns and lesions of viscera and other special structures is required. These subjects are found dealt with under their respective heads. The student of first aid should be familiar with all of these principles. Especially is knowledge of the treatment of wounds essential.

Badly injured parts should be exposed by removal of the clothing. If the movements of the parts might be at all harmful, the clothing should be cut off from the injured region.

The transportation of the injured to a place where deliberate and careful attention can be given is most important.

Fig. 2214.

Fig. 2215.

Fig. 2214.—One Man Carrying Injured Person (Second Position).

The carrier swings the patient about, encircles his pelvis with his right arm, places his head between the patient's right arm and body, grasps with his right hand the patient's right wrist, grasps the patient's left wrist with his left hand across his back, and rises.

Fig. 2215.—One Man Carrying Injured Person (Third Position).

As the carrier arises to the standing position, he grasps the patient's left hand, and continues to hold the patient's right wrist with his right hand. The carrier's right arm thus encircles the patient's thighs, and the patient lies prone across the carrier's shoulders.

In emergencies in which but one man is available for an unconscious person, he may be carried on a travois drawn by a man; or he may be thrown transversely across the shoulders of the carrier (Figs. 2213, 2214 and 2215).

Another method which leaves the carrier's left arm free is shown in Figs. 2216, 2217 and 2218.

Another method is as follows:

The carrier raises the person to a sitting position, grasps the left wrist with his left hand, drops on his knee, puts his head under the left arm so that the axilla rests on the back of his neck, then, as he rises to a standing position, he draws down on the left arm, lifts up the legs with his right arm, and throws the patient across his shoulders in such a way that the latter lies on his left side, the left chest resting on the carrier's left shoulder, the left

thigh on the right shoulder, and the abdomen against the back of the carrier's head.

A person who can sit up and use his arms may be transported upon the hands and arms of two carriers, grasping one another's wrists (Fig. 2219).

FIG. 2216.—ONE MAN CARRYING WITH HAND FREE (FIRST POSITION).
The carrier kneels before the prone patient, places his hands under his axillæ and lifts him to the standing position.

FIG. 2217.

FIG. 2218.

FIG. 2217.—ONE MAN CARRYING WITH HAND FREE (SECOND POSITION).
The carrier bends forward, places his right hand behind the patient's left knee and his shoulder under the patient's right axilla. Grasping the patient's right hand with his left hand the carrier rises.

FIG. 2218.—ONE MAN CARRYING WITH HAND FREE (THIRD POSITION).
As the carrier rises, the patient is swung prone across his right shoulder and the patient's right wrist grasped by the carrier's right hand. This leaves the carrier's left arm free.

Or if the patient is helpless he may be supported on the three arms of two carriers (Fig. 2220).

For the use of the unconscious and the seriously injured, who are to be moved by hand, the *stretcher* is most useful. This is made of strong canvas,

stretched between two strong poles. The canvas bed should be about 2 meters (6 feet) long and 75 cm. (2½ feet) wide. The poles should project 15 cm. (6 inches) beyond the canvas at either end as handles (Fig. 2220*a*). In walking the carriers should not keep step.

For transporting the injured on vessels, or from one vessel to another, it is necessary that they should be made fast to the stretcher. The *apron stretcher* consists of a wooden frame over which is stretched a canvas covering, having attached to it two flaps which may be laced over the patient. This stretcher has canvas handles for carrying, or a rope may be attached to the top and the patient swing across a space by the hoisting devices common to vessels (Fig. 2221). If the ordinary stretcher requires much handling or the patient must be carried over rough places, the patient may be fastened

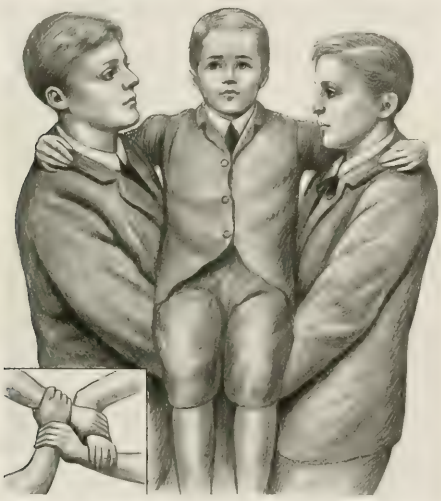


FIG. 2219.—PATIENT CARRIED BY TWO CARRIERS GRASPING ONE ANOTHER'S WRISTS.

to the stretcher by bandages or straps so that the stretcher may be stood on either end or turned upside down without dislodging the patient.

An *improvised stretcher* may be made from two coats and two poles or oars. The poles are thrust through the sleeves of the coats, so that the tops of the coats come together at the center of the stretcher. The skirts of the coats are wrapped around the poles and fastened with safety pins or with extemporized pins of wood, iron, or wire (Fig. 2222).

Two, three, or four persons of about the same height, should carry a stretcher. They should not walk in step as the patient is jarred less if they are out of step.

The use of a door, shutter, or board for carrying the injured is to be deprecated. Such things are hard for the carriers to hold; and the patient suffers from the fear of insecurity. A stretcher should be constructed whenever possible.

For transporting for long distances by horse power, the stretcher used by the American Indians, known as the *travois*, is very effective. It consists of two long poles, made of young trees harnessed to the horse, like the shafts of a wagon. The small ends, retaining some brush if the road is rough, drag

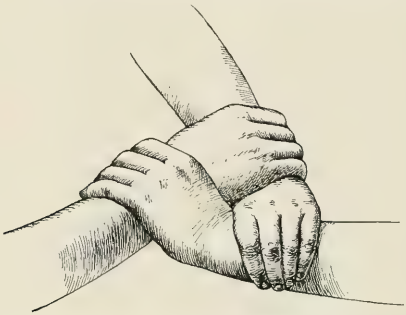


Fig. 2220.—Seat Made of Three Hands.
This leaves one arm of the carriers free to hold a helpless person.

on the ground. A stretcher is constructed between the two poles. If the ground is even the heavy ends may rest on the ground (Fig. 2222*a*).

Two horses may carry a stretcher (Fig. 2222*b*). A stretcher may be slung on either side of the saddle of a pack horse and two persons carried

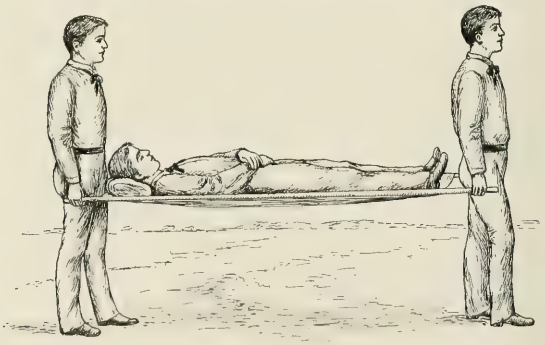


Fig. 2220*a*.—Stretcher.
Two persons acting as carriers for patient on stretcher.

(Fig. 2223). The two wheels of a carriage serve to carry a stretcher (Fig. 2224). A stretcher on bicycle wheels may be attached to a bicycle, tricycle or motorcycle (Fig. 2225).

Where a wagon or railroad car is available the patient may be put on a bed, a cot, or a mattress, either with or without the combination of a

stretcher. If a long journey is to be undertaken, clothing should be removed or so arranged that the bowels and the bladder may be evacuated without trouble. In the case of a helpless person, a stretcher may be arranged with an opening under the pelvis, such as is used in the treatment of children with tuberculosis of the spine (see Vol. II, page 329).

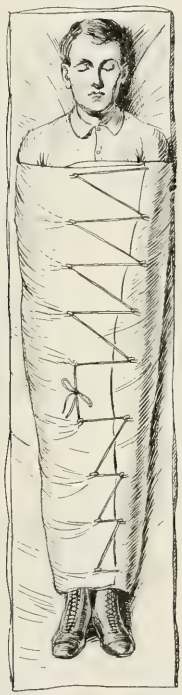


FIG. 2221.

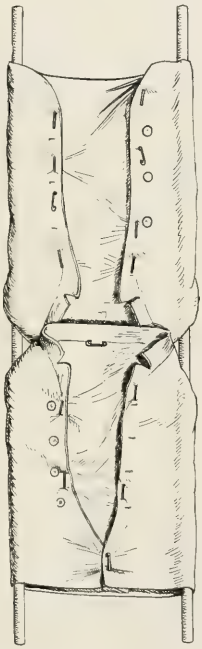


FIG. 2222.

FIG. 2221.—APRON STRETCHER.

This permits fastening patient to the stretcher for transportation in any position.

FIG. 2222.—COAT STRETCHER.

Extemporized by running poles through arms of coats and pinning the coats with safety-pins, pegs, nails, or wire pins.

The most satisfactory means of transportation is by the *ambulance*, a vehicle constructed with bed and stretcher. The springs of such a vehicle should not be too elastic as in going over obstacles the patient is apt to be tossed up from the bed. The modern *shock absorbers* used on automobiles for taking up the motion of obstacles should be placed on ambulances. Ambulances are propelled by horses, electricity, and hydrocarbon fuels. The

modern motor ambulance (Fig. 2225*a*) is a highly perfected vehicle. It is made with accommodations for one or for several patients and is provided w th many of the appurtenances of hospital equipment (Fig. 2225*b*).

The heavy service ambulance, such as is used by the U. S. Government, is capable of carrying four patients on stretchers (Fig. 2225*c*). The same

Fig. 2222*a*.—American Travois

ambulance principle is applied to railway coaches (Fig. 2225*d*) and to steamboats. The ultramodern method for carrying the disabled has been by means of the aeroplane, as suggested by Chassing. This permits rapid transportation over areas which are impassable for vehicles which must move by land or water. (See N. W. Sharpe, Ann. of Surg., Nov., 1918, p. 526.)

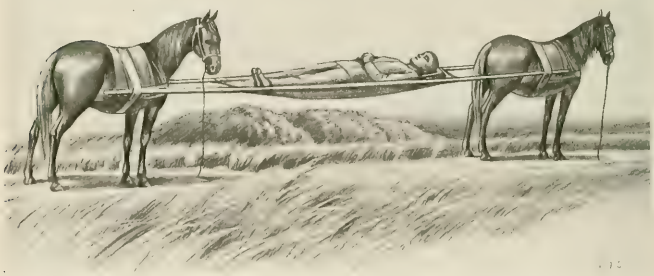


Fig. 2222*b*.—Stretcher Carried by Two Horses.

Respiratory resuscitation apparatus is especially useful in the physiological laboratory. It is desirable to have such apparatus where patients may need resuscitation, provided that persons are present always with the apparatus who understand how to use it. But to have such apparatus at places where patients must be brought or from which the apparatus must be

fetched is worse than useless; and inasmuch as these are usually the conditions under which the apparatus is employed, it should not be depended upon.

The ordinary methods of respiratory resuscitation of Schäfer or Sylvester, referred to below, are much more valuable. They require no apparatus,

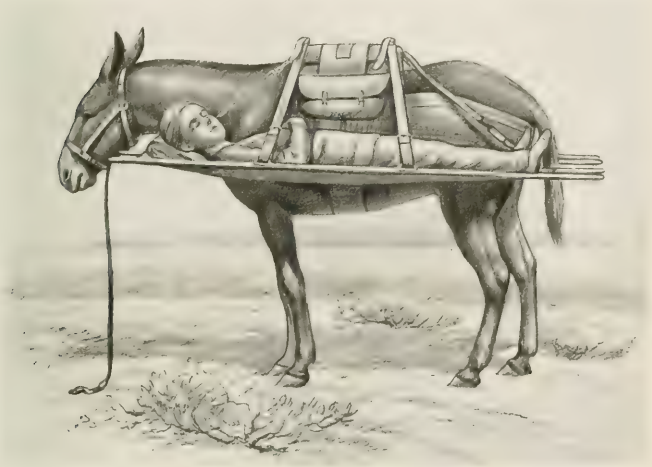


FIG. 2223.—STRETCHERS ON PACK-MULE.

they can be applied immediately, and they demand less skill and intelligence than are required for the use of machines.

Apparatus for resuscitation is found so widely in use and reported through the press as capable of such wonderful performances in saving life because

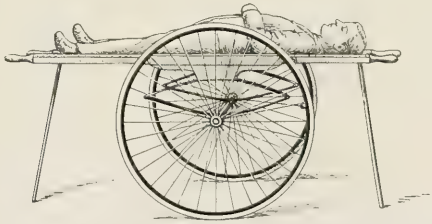


FIG. 2224.—STRETCHER ON TWO WHEELS

somebody is making profits out of it. On the whole these things have done more harm than good. People who might have been saved by simple methods have been carted off to the place where the much-lauded apparatus was to be found, and bystanders have stood idly about while apparatus was

sent for and precious time was wasted. Many deaths are directly chargeable to these devices and their exaggerated claims. The medical profession as well as the public has been humbugged by these things, the reputations of which have been gained largely by their use on persons who were breathing without apparatus, and by the corruption of the press.

In respiratory failure by drowning, anesthetic poisoning, gas, electric shock, when respiration stops, the possibilities of restoration rapidly diminish as the seconds pass. During the first minute the best restorative is rhythmic pressure upon the chest. This is better than pulmonary suction and inflation by apparatus, even though the latter could be applied. After two or three minutes have elapsed, in most cases, no method will restore respiration. If respiratory apparatus is at hand at the place and minute when it is needed, such apparatus, if in good working order, is probably more capable of reproducing respiration which is near normal than are efforts without apparatus. The danger is that the simple methods are neglected while the much vaunted apparatus is sent for.

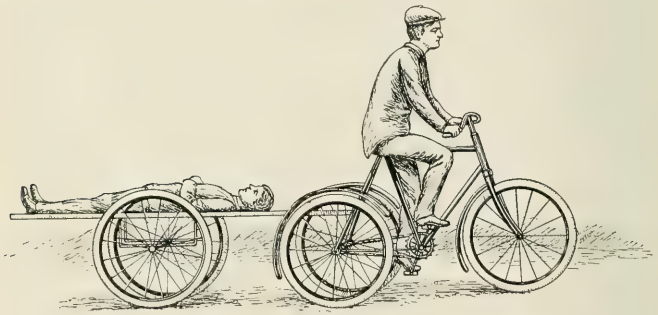


FIG. 2225.—STRETCHER ON WHEELS ATTACHED TO TRICYCLE.
The bicycle or motor cycle may be used for the same purpose.

Intratracheal insufflation is preëminently the most potent method of resuscitation in cases in which simple manual methods fail. Unfortunately, for its use are required skill and apparatus (see Vol. II, page 446).

Artificial respiration, without apparatus, is the simple method of resuscitation in cases of respiratory failure. It should be taught in the schools and known by everybody. It has great possibilities in saving life. It can not be patented, controlled, or exploited by any commercial interests. It should be applied at once in cases in which breathing has stopped because of some condition which is not necessarily fatal. It is capable not only of restoring respiration, but a heart which has stopped may be stimulated into action by this simple procedure. The best method is the method of Schäfer (see page 717). For the patient who cannot be turned to the prone position, the method of Sylvester is to be used (see page 719).

Mouth-to-mouth inflation is useful in children. The tongue is held forward by means of a suture or a string tied around it. The nostrils are held together by the fingers. The operator applies his opened mouth over the mouth of the child and exhales into the child's mouth. This inflates the lungs of the child. The air is then expelled by pressure on the patient's chest;

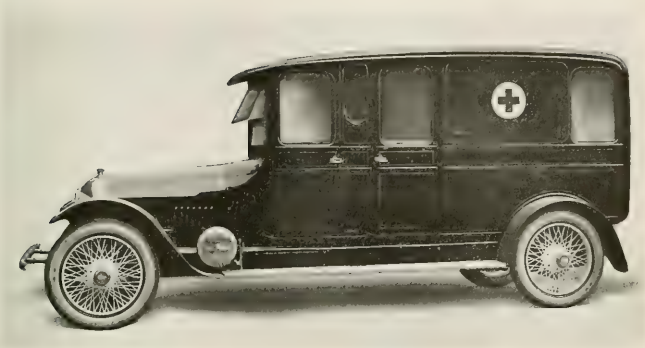


FIG. 2225a.—MODERN AMBULANCE.
Type of gasolene-driven vehicle used in connection with hospitals and other institutions.

FIG. 2225b.—INTERIOR OF MODERN AMBULANCE.
This is the vehicle commonly employed by city hospitals.

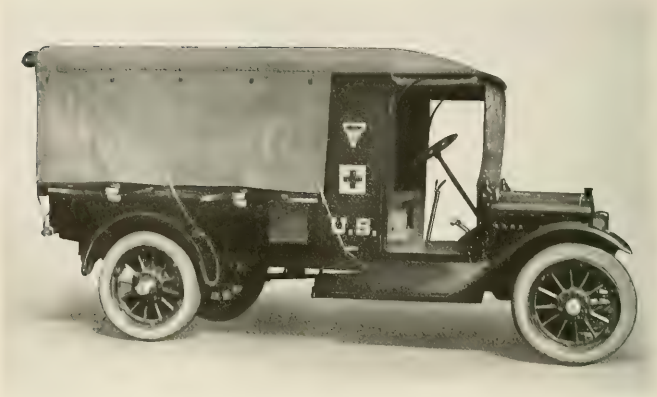


FIG. 2225c.—MODERN SERVICE AMBULANCE.
Type of gasolene-driven vehicle, adapted to rough service, fitted with two tiers of stretchers capable of carrying four patients.

FIG. 2225d.—AMBULANCE RAILWAY COACH.
This coach is fitted with beds for carrying a large number of patients with all the comfort of the modern sleeping car.

and the inflation repeated. This should be done about 16 times a minute. If haste is necessary the operator may apply his mouth over the patient's nose and mouth. Instead of this method a catheter may be passed into the patient's larynx, and inflation practised through the catheter.

Asphyxia, due to mechanical obstruction in the respiratory tract should be treated by removing the obstruction. The surgeon's first duty is to discover what is the cause of the obstruction. Foreign body in the pharynx may often be removed by passing the finger to the back of the mouth. Tracheotomy may be necessary for a body located in the larynx or trachea. If there is obstruction of the larynx due to edematous swelling intubation or insufflation is indicated. Plenty of fresh air should be admitted.

Drowning is asphyxia caused by submerging in fluid. Resuscitation may be successfully applied after two minutes of submerging. Cases have been revived after five minutes. One case is reported of recovery after twenty-five minutes. The lungs, stomach and mouth should be emptied of water by rolling the patient on the abdomen with the head lower than the body. After a few seconds the mouth should be opened, the tongue drawn out, and the patient placed in position for artificial respiration. As artificial respiration, by one of the methods described above, is applied, the clothing should be loosened and every effort made to make the patient warm. The wet clothing should be removed if the air is cool, and the skin should be dried and rubbed. Warm blankets or hot bottles should be applied to the surface of the body. The operation should be carried on in the fresh air, but if the air is very cold the patient should be in a warm place. Warmth is more important than fresh air.

The most important thing is artificial respiration. Every second counts. The sooner artificial respiration is begun, the better. As soon as the patient begins to breathe the manipulations may be discontinued, but should be resumed again, if breathing stops. As soon as the patient can swallow he should be given warm drinks. When breathing first begins, it should be helped by the artificial motions. Secondary respiratory failure should be watched for.

Smoke asphyxia should be treated by bringing the patient to the fresh air and loosening the clothing. If the patient is conscious and seems nauseated, he should be encouraged to vomit by taking a large drink of warm water. Vomiting brings up mucus and gas from the stomach. If the patient is unconscious, the body should be kept warm, and the patient put to bed. If respiration has stopped, artificial respiration should be applied at once. If edema of the glottis has been caused by irritating gases, tracheotomy should be done. The irritation of the eyes is treated with boric acid solution and ice-cold compresses.

Hanging, producing asphyxia by compression of the trachea, should be treated by removing the constriction as quickly as possible. The subsequent treatment is much the same as that of drowning. Artificial respiration should be started promptly. If the larynx or trachea have been fractured tracheotomy should be done below the injury because of the possible presence of edema of the glottis.

The treatment of wounds has been discussed in Vol. I. The cleansing and closing of fresh wounds must be carried out with due regard to the possibilities of infection which threatens all wounds. This has all been fully described.

The control of hemorrhage is described under that heading. The treatment of injuries of special structures has also been described.

The treatment of infected wounds may be summarized as follows:

Infected wounds before inflammation has begun should be treated by mechanical cleansing, removal of foreign and dead material, and physiological rest. Physiological rest means rest for the patient and immobilization of the wounded part without disturbance of circulation. There should be free escape for discharges. If there is strong probability of serious infection, the wound may be treated first with hypochlorite solution, dichloramin-T, eusol, flavin, "bipp," or magnesium. If the probability of serious infection is not great salt solution suffices.

Acutely infected wounds should be treated by the above methods with the addition of hot applications. If haste is necessary drainage at dependent places is called for. If time can be taken the wound should be cleansed and treated by hypochlorite solution or dichloramin-T without dependent drainage. "Bipp" may be used if the depths of the wound can be reached by it.

Healing wounds may be hastened in their process by exposure to sunlight or other actinic rays. Hypertonic salt solution is useful. A chlorin-liberating antiseptic will kill bacteria and promote healing.

BANDAGING

Bandages are used to retain splints or dressings, to make pressure, to restrain joints, to correct deformities, and to give support. The materials used and the methods of preparing bandages are described in the chapter on Surgical Materials (Vol. I, page 55). A bandage should be strong enough to permit of being firmly applied and of such texture as to lie smoothly. Muslin fulfills these requirements. Gauze has the advantage that it is slightly elastic; but it is not firm, and it easily becomes wrinkled and uneven. Gauze is of especial value in retaining wound dressings. For making gentle surface pressure on the skin, the flannel or tricot bandage has the advantage of being both elastic and firm; these materials hold their shape well, and are soft, neat, and capable of adjustment.

For the head, gauze and muslin are used; for the trunk and larger limbs, gauze and unbleached muslin; for the smaller members and fingers, bleached

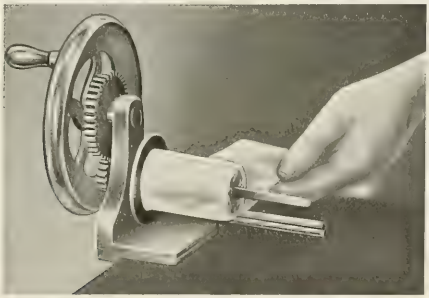


FIG. 2226.—HAND ROLLER-BANDAGE MACHINE.

muslin and gauze are preferred. When bleached muslin is used, it is well to wet the roll to cause the layers better to adhere and conform.

Bandages should be applied so that they lie flatly upon the skin. One edge of a bandage should not be tighter than the other. There should be no seams or edges to make uneven pressure. No part of a bandage should be tighter than another. The pressure should be equally distributed and the bandage should be smooth. It is especially important that the upper part of a bandage on a limb should not be tighter than the lower part; if it is, venous return is impeded and gangrene or ischemia may result. It is best that the turns of a bandage on a limb should run obliquely. The oblique bandage permits of expansion and contraction, which the circular bandage does not. A circular bandage should not be applied around a limb unless the rest of the distal part of the limb also is covered with a bandage, or unless the bandage is very loose. If this rule is not observed, dangerous swelling may occur.

A bandage should not cause discomfort. If a bandage causes pain it should be removed.

Depending upon the direction of the application bandages are called circular, oblique, recurrent, spiral, reversed, crossing, longitudinal and

FIG. 2227.—ROLLING A BANDAGE BY HAND (FIRST METHOD).
This method best insures a tight roll.

figure-of-eight. Suspensory, spica, T-bandages, retention, restraining and pressure bandages are also used.

The materials for bandages are best rolled by machinery (Fig. 2226), as already described, but for extemporizing or for rewinding a bandage the

FIG. 2227*a*.—ROLLING BANDAGE BY HAND (SECOND METHOD).
This method best insures an even roll.

surgeon may roll it by hand (Fig. 2227). The bandage should be firmly rolled or it becomes disorganized in its application (Fig. 2227*a*).

When a bandage is to be removed, the pin or other end fastening may be released, and the bandage unwound into a ball, to be rewound and used again;

or the bandage may be cut away with scissors. Bandage scissors are best for this purpose (Fig. 2228).

A bandage should be applied so that it looks well. The edges should be parallel and even, the bandage neat and smooth. An esthetically applied bandage gives pleasure to the patient and satisfaction to the surgeon. An uneven, wrinkled, disorderly looking bandage is not in keeping with good surgery.

The fixation of bandages is improved by a few pins, stitches of thread, or a strip of adhesive plaster, applied at the points where the bandage may slip.

Rules for Bandaging.—Bandages should not be applied to dirty parts. The skin should be clean. The patient should be in a comfortable position. The part to be bandaged should be freely accessible. If it is a limb, it should be supported. The surgeon stands facing the patient. The end of the bandage is applied and fixed by making two or three turns of the roller to hold it. The side of the roll from which the bandage is rolling should be toward the skin. The roller is held in the right hand and guided and smoothed with the left as it is applied. Each turn should cover about two-thirds of the preceding turn, thus each layer holds its predecessor.

Fixing the bandage to prevent displacement is highly important. A skillfully applied bandage on a patient who remains quietly requires little fixation further than fastening the end. This is best done with safety-pins in the larger parts and by tying in the smaller parts (Figs. 2229, 2230 and 2231). Adhesive plaster is also useful in fixing the ends.

To tie the end of a bandage, it should be split in the center lengthwise, and one side carried around the part in one direction and the other in the other direction, and tied. Or a loop may be carried to one side and the free end to the other.

It is also important that the several layers be prevented from slipping over one another. For this purpose pins or adhesive plaster may be used. A bandage which is to remain on for a long time may be caught with needle and thread and thus secured. A simple device consists in laying under the bandage against the skin and between the folds longitudinal folds of adhesive plaster, which have been folded double lengthwise so that the adhesive surface is exposed on both sides. Two or three such strips under a bandage are concealed and prevent slipping (Fig. 2232).

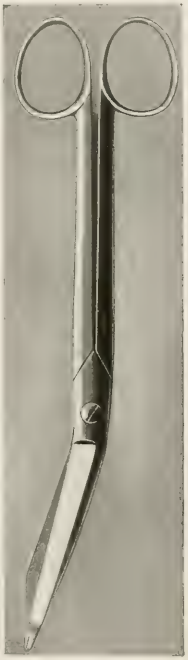


FIG. 2228.—BANDAGE SCISSORS.

For cutting bandages on the patient. The button on the end of the lower blade prevents injury of the skin.

Gauze and flannel keep their positions well. Muslin requires to be fixed. Bleached muslin remains in position better if the bandage is wet before it is applied.

The Simple Forms of Bandage.—1. The *circular bnadage* is made by applying the roller round and round without ascending or descending.

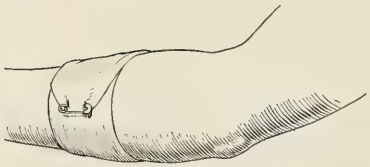


Fig. 2229.—Method of Fixing the End of a Bandage by Pinning.

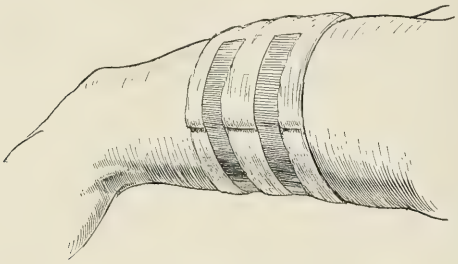


Fig. 2230.—Fixing the End of a Bandage with Adhesive Strips.

Fig. 2231.—Fixing the End of a Bandage by Tying.

Such bandages are applied to the neck, wrist or ankle and should never be tight. Several layers are applied each overlying the other (Fig. 2233).

2. The *oblique bandage* consists of spiral turns, not overlapping one another. Such bandages are used to retain loose dressings (Fig. 2234).

FIG. 2232.—ADHESIVE STRIPS USED TO HOLD BANDAGE SECURE.

The strips of adhesive plaster are doubled longitudinally and placed under the bandage with the adhesive surface out. One surface adheres to the skin, the other surface adheres to the bandage.

3. The *spiral bandage* is obliquely applied but each turn overlaps one-third of the underlying turn. Such bandages are used on the chest, abdomen, limbs and parts which have parallel sides or which do not greatly taper. In

FIG. 2233.—CIRCULAR BANDAGE APPLIED TO NECK.

a slightly tapering limb a spiral bandage may pass from the smaller part toward the larger part but not in the reverse direction (Fig. 2235).

4. The *spiral reverse bandage* is begun as the spiral bandage. The end is fixed by several turns to hold it, or it is the continuation of some other form.

FIG. 2234.—OBLIQUE BANDAGE.

FIG. 2235.—SPIRAL BANDAGE.

FIG. 2236.—SPIRAL REVERSE BANDAGE.
Showing manner of application.

The bandage is carried obliquely up the limb; the surgeon's left thumb presses the bandage and holds it against the front of the limb; at the same time the right hand, holding the bandage, reverses it, making a half turn, and starts the bandage obliquely downward (Fig. 2236). This process is repeated. Each reverse should be in the middle anterior line of the limb, so

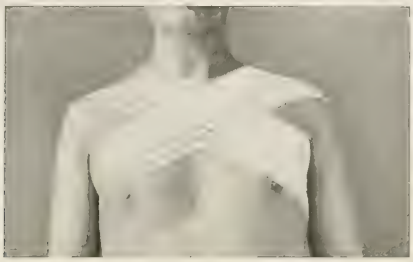


FIG. 2238.—ANTERIOR FIGURE-OF-EIGHT BANDAGE OF CHEST.

that the reverses lie evenly, and the spaces between the edges of the bandage are equal. This is the method of applying a bandage to the leg, forearm, and tapering thigh.

5. The *figure-of-eight bandage* is used where a member or part projects from another part. It is useful in bandaging the wrist and thumb, chest and

FIG. 2239.—ASCENDING SPICA BANDAGE OF GROIN.

upper arm, and the chest and neck. It requires that the bandage should pass around each part and cross between them (Fig. 2238).

6. The *spica bandage* is used at joints, such as the groin, shoulder and thumb. It is similar to the figure-of-eight except that it is carried further and caused to cover more surface. Each turn covers two-thirds of the preceding turn, giving a weaving or decussating effect (Fig. 2239).

The *weaving bandage* is applied also to a limb which has two variations in thickness, such as the calf or a very muscular forearm. Here a real spica may be applied without ulng ay reverses (Fig. 2284*a*).

7. The *recurrent bandage* is used to cover the head or the ends of limbs or members. The bandage is passed back and forth, each loop being held by a circular bandage, passing around the part (Fig. 2241).

BANDAGES OF SPECIAL REGIONS

Bandages of the Head and Neck.—The *universal head bandage* is applied with a roller 5 cm. (2 inches) wide. This bandage is used for the scalp, face, and lower jaw to retain dressings, to immobilize the jaw, and to control fractures. The beginning end of the bandage is placed on the scalp just behind the mastoid process. Thence it passes below the occipital protuberance, obliquely upward and forward, across the parietal eminence to the middle of the top of the head; thence downward on the opposite side, across the zygoma, and under the chin; thence upward across the opposite zygoma, over the top of the head, crossing the first turn at the median line of the vertex; thence backward and downward across the parietal eminence or below it to the occiput. At the latter point it now lies upon the beginning and holds it. The bandage then continues forward horizontally under the ear, across the front of the chin, and thence back on the other side to the occiput. From the occiput it passes upward and forward, above the ear, across the front of the forehead, and back on the other side above the ear to the occiput.

Fig. 2241.—Recurrent Bandage for Covering Ends of Extremities.

The same procedure is then repeated as from the beginning, layer on layer, each crossing turn holding the underlying turn in place. The last turn should be about the forehead, and the last jaw turn should be vertical (Fig. 2242). A small safety pin should be inserted at each place where the turns cross. The forehead piece may be omitted. This bandage is used for the scalp, face and lower jaw, to retain dressings, to immobilize the jaw, and to control fractures.

The *head bandage with median piece* as made with a 5-cm. bandage. It is begun at the vertex of the skull, and passes down in front of the ear, under the chin, up on the opposite side of the face, to the point of starting. This is repeated until three turns have been made. As the third turn is completed a reverse is made just above the zygoma by inserting a pin at an angle of 45 degrees. From this point the bandage is carried three turns around the head, crossing the occiput and the forehead. Thence it passes from the occiput, after being pinned, below the ear, across the front of the chin, and back to the occiput. This latter course is followed 3 times. The bandage is then pinned at the occiput in the middle line and carried forward in the median line to the forehead, where it is pinned to the forehead bandage. Wherever the turns cross they are pinned together (Fig. 2243). The use of this bandage is the same as the above.

Cheek bandage is made with 5-cm. (2-inch) wide material. It is begun just above the left ear if the left side of the face is to be covered. It passes back to the occiput and thence across the forehead. Three turns are made in this direction. Then it proceeds below the ear on the well side, under the jaw, up on the side of the face to be covered, the anterior edge lying close to the outer edge of the orbit, across the vertex and down behind the ear. It passes thus vertically around the head 3 or 4 times, each ascending turn on the left side passing a little further back than the preceding one, until the posterior edge of the last turn touches the ear. The bandage is then reversed at a point just above the right ear, pinned, and carried 1 or 2 times around the occiput and forehead. Pins are inserted where the

FIG. 2242.—UNIVERSAL HEAD BANDAGE.

turns cross (Fig. 2244). The use of this bandage is to retain dressings on the side of the face.

Crossed facial bandage is applied with a 5-cm. (2-inch) roller. It begins at the vertex, passes down in front of the ear, under the jaw, and up on the other side of the vertex. Two or three turns are made in this course. A reverse is then made at the side of the head, a pin inserted, and two or three turns carried about the occiput and forehead. Pins should be inserted on either side where the bandage crosses (Fig. 2245). To make this more secure a reverse may be made at the occiput and a strip carried forward in the median line to the forehead and pinned at three places. This bandage is used to retain dressings on the scalp, face, and chin and to control the lower jaw.

Forehead-chin bandage is made with a roller 5 cm. (2 inches) wide and 4 meters long. Two or three turns are made around the occiput and forehead. Then from the occiput the bandage is carried 2 or 3 times across the front of the chin, alternating with turns around the forehead (Fig. 2246).

This bandage is useful in holding dressings on the chin and lower lip.

Forehead-mouth bandage is the same as the above except that the bandage passes across the upper lip instead of the chin (Fig. 2247).

Fig. 2243.—Head Bandage with Median Piece.

Forehead-neck bandage is made with a roller 5 cm. (2 inches) wide and 4 meters long. Two or three turns are made around the forehead and occiput;

Fig. 2244.—Cheek Bandage.

and then alternating turns are carried around the neck and forehead (Fig. 2248). It is useful in retaining dressings especially on the back of the neck.

Double lateral scalp bandage is made with a roller 5 cm. (2 inches) wide.

FIG. 2245.—CROSSED FACIAL BANDAGE.

FIG. 2246.—FOREHEAD-CHIN BANDAGE.

It begins at the occiput, and the end is secured by two turns about the forehead and occiput. Then the bandage passes obliquely from the occiput across the parietal eminence to the forehead, around the side of the head, back to the occiput, following the first turn to the forehead; and thence obliquely rising from the forehead, it passes across the opposite parietal eminence and back to the occiput. From the occiput it passes obliquely upward and forward across the side of the head covering two-thirds of the last oblique turn. The same oblique course is taken on the other side from before backward. Thus on either side of the parietal eminences the turns successively pass lower and lower until the bandage reaches the level of the initial turns (Fig. 2249).

This bandage is used to retain dressings on the scalp and to make pressure.

Fronto-occipital bandage is made with a roller 5 cm. (2 inches) wide and 4 meters long. It is begun at the occiput low down; and thence it passes high

Fig. 2247.—Forehead and Mouth Bandage.

across the forehead. Each turn across the occiput passes a little higher than the preceding turn, and each turn across the forehead passes a little lower than the preceding. At the end the bandage is pinned at the side (Fig. 2250).

This is a most useful bandage for dressings of the forehead or occiput.

Antero-posterior capitellum bandage is made with a roller 2.5 cm. (1 inch) wide and another 5 cm. (2 inches) wide. The first is passed about the forehead and occiput, above the ears as low as possible, two turns. The wider bandage is then fixed by placing its end at the occiput and held by a turn of the circular bandage. It is then carried forward in the median line to the forehead. The circular bandage crosses it here. As soon as it is caught beneath the circular bandage it is carried back to the occiput again and again caught under the circular turn. Thus one bandage passes round and round the head, and the other backward and forward. The latter is passed first

to one side of the median line and then to the other side, constantly working toward the ears as the middle of the scalp is covered. When the reversing

FIG. 2248.—FOREHEAD-NECK BANDAGE.

bandage has covered the entire scalp, the narrower bandage is cut and a few circular turns made to cover it (Fig. 2251).

FIG. 2249.—DOUBLE LATERAL BANDAGE OF SCALP.

This bandage is used to cover the entire scalp, especially for retaining dressings.

Transverse capitellum bandage is applied the same as the above except that

the reverses are made transversely instead of backward and forward (Fig. 2252).

Single capitellum bandage is applied by making two or three turns around the head and then making a reverse at the occiput and from that point revers-

Fig. 2250.—Fronto-occipital Bandage.

ing the bandage back and forth from occiput to forehead and from forehead to occiput as in the above until the whole scalp is covered. If the surgeon's left hand is large enough he may hold the folds at the front and back with one

Fig. 2251.—Capitellum.

hand; if not an assistant or the patient must put his fingers on each fold at one place as the folds are made. When the scalp has been covered, the bandage is carried about the head just above the ears for a few turns, and the reverse ends pinned to the circular turn.

Oblique bandage of the eye is made with a 5-cm. (2-inch) bandage. It begins by making two or three turns around the forehead and occiput. Then it passes from the occiput below the ear, obliquely upward across the face

FIG. 2252.—TRANSVERSE CAPITELLUM.

and eye, across the parietal eminence, and back to the occiput; thence it passes over the same course, except that each turn as it crosses the face passes

FIG. 2253.—OBLIQUE BANDAGE OF THE EYE.

a little further outward, leaving exposed one-third of the underlying bandage. The bandage may continue until the ear is covered. When enough oblique

turns have been made, one or two turns are carried about the forehead, and a few pins inserted for security. If the ear is included in the bandage, gauze should be placed back of the ear so that it is not pressed against the scalp (Fig. 2253).

This bandage retains dressings on the eye, cheek or ear, and may be modified to suit the situation.

Crossed bandage of the eyes is best made with a 5-cm. (2-inch) roller. Two circular turns are made about the forehead and occiput. The roller is then carried from the occiput below the ear, forward and obliquely upward across the face and eye to the opposite parietal eminence, and down to the occiput. A circular turn is then made across the forehead; when this reaches the occiput the bandage passes up to the parietal eminence, down across the eye and cheek, under the ear and back to the occiput. A turn is again made across the forehead, and the first oblique course again followed except that the underlying bandage is left one-third exposed. After one, two or three oblique turns have been made on each side, a turn or two is made across the forehead and the bandage pinned (Fig. 2254). If desired the ears may be covered.

FIG. 2254.—CROSSED DOUBLE BANDAGE OF THE EYES.

This bandage is used to cover both eyes or cheeks. For holding dressings on the diseased eyeball it has the disadvantage that it makes pressure, and for this reason the eye shield is better.

Bandage of ear is an occipitofrontal bandage covering the ear (Fig. 2255).

Simple bandage of the neck is made with a roller of firm muslin. Enough turns are carried about the neck, passing as high as the jaw and as low as the clavicle, to make a firm collar (Fig. 2233). To prevent such a dressing from slipping it may be caught to the skin by an adhesive strip. For retaining dressings to the back of the neck, the bandage may be prevented from wrinkling by incorporating a few layers of adhesive plaster or stiff paper at the back of the neck (Fig. 2256).

A *thyroid bandage* of the neck may be applied without passing under the arms. A bandage 4 cm. wide is used. It is begun as a circular bandage of the neck and continued as a spiral reverse as it descends. The reverses are made in the middle line in front, and are continued as far as the sternum. To hold the downward projecting bandage, an adhesive plaster strip is placed

FIG. 2255.—BANDAGE OF THE EAR.

FIG. 2256.—BANDAGE OF NECK STIFFENED BY THE ADDITION OF ADHESIVE PLASTER TO PREVENT DISPLACEMENT.

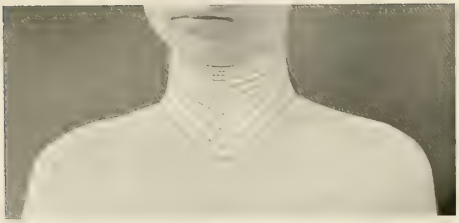


FIG. 2256*a*.—THYROID BANDAGE.

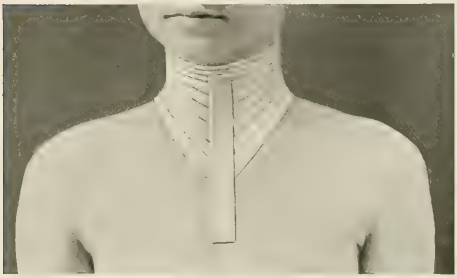


FIG. 2256*b*.—THYROID BANDAGE FIXED WITH ADHESIVE PLASTER.

FIG. 2257.—BANDAGE OF THE NECK AND AXILLA.

in the middle line to hold the folds of the bandage together and to prevent upward displacement of the bandage. This bandage was devised by H. J. John (Figs. 2256*a* and 2256*b*).

Bandages of the Upper Extremities.—*Bandage of the neck and axilla* is applied by carrying two or three turns around the neck, then the bandage passes across the clavicle to the axilla, back across the clavicle to the neck, around the neck and again under the axilla. As many turns as are necessary may be made. Each layer across the clavicle should cross the preceding layer and not lay parallel with it (Fig. 2257). This bandage is useful for retaining dressings on the neck and axilla. It is better than the simple neck dressing as it can not rotate and become displaced.

FIG. 2258.—ASCENDING SPICA OF SHOULDER.

Ascending spica of shoulder is applied with a 6.5-cm.(2½-inch) roller. The bandage is begun by placing the end on the outer side of the arm opposite the axilla and passing it forward and around the arm as high as possible. Three circular turns are thus made. Then it passes obliquely upward and inward, across the front of the chest, under the opposite axilla, across the back to the outer side of the arm, around the arm, across the chest, under the opposite axilla, across the back, and so on repeating its course. Each turn around the arm mounts slightly higher, covering about two-thirds of the preceding turn. Under the opposite axilla each turn lies directly upon the preceding one. A decussating, weaving effect is thus secured, mounting upward over the shoulder. This may be carried as far as the side of the neck if desired (Fig. 2258).

This bandage is useful for retaining dressings to the shoulder and for making pressure. A stiff bandage may be used to immobilize the shoulder.

Descending spica of shoulder is similar to the above except that its course of application is reversed. The bandage is begun by making two or three cir-

FIG. 2259.—DESCENDING SPICA OF SHOULDER.

FIG. 2259a.—BANDAGE OF SHOULDER AND ARM OF VELPEAU. (*Whiting.*)

cular turns about the upper arm. The bandage should be passed under the axilla, over the shoulder close to the neck, under the opposite axilla, and back again close to the neck. The returning bandage should cross the first turn

on the shoulder near the neck. Each turn should cross its predecessor a little further outward until the shoulder is covered and the upper arm and axilla embraced. The end may be fastened away from the arm (Fig. 2259) or one or two final turns may be made about the arm to fix the end. This bandage is not as satisfactory as the ascending spica.

Immobilizing bandage of shoulder and arm (Velpeau) is applied with two rollers 6.5 cm. (2½ inches) wide and 6 meters long. The patient should sit upright and place the fingers of the affected side on the clavicle of the opposite side. A pad of gauze to absorb skin secretion should be placed in the axilla. The bandage should be started back of the scapula of the well side. The bandage should be carried over the shoulder of the affected side as far outward as possible, thence downward along the outer and posterior aspects of the arm, behind the elbow (Fig. 2259*a*), obliquely across the front of the chest to the axilla of the sound side, and thence to the place of starting. This turn should be repeated. Then the third turn is carried transversely

FIG. 2260.—BANDAGE OF SHOULDER AND ARM. (*Velpeau.*)

around the chest, crossing the arm and forearm close to the elbow, and thence under the axilla to the place of starting. This last turn presses the elbow against the trunk. The roller is then carried over the shoulder of the affected side, and below the axilla to the place of starting. Thence it passes transversely around the chest covering about one-half of the preceding transverse turn.

This alternating course is continued, turns over the shoulder and down the arm alternating with transverse turns around the chest. Each vertical turn over the shoulder and down the arm should cover about two-thirds of the preceding turn. The bandage follows this course, the vertical turns moving inward and the horizontal turns moving upward, until the former impinge upon the neck and the latter reach the hand as it lies on the chest (Fig. 2260).

This bandage is used to immobilize the shoulder joint, and to hold the clavicle and humerus in certain fractures of those bones.

Immobilizing bandage of shoulder (Desault) requires three rollers, each 6.5 cm. (2½ inches) wide and 6 meters long. A pad of gauze is placed in the axilla. The arm of the patient is held away from the body.

The first roller is begun at the axillary pad at the top of the axilla. The

bandage passes horizontally around the chest as a descending spiral as far down as the end of the sternum; thence it is continued around the chest as

FIG. 2261.—BANDAGE OF SHOULDER AND ARM (DESAULT).
First roller.

FIG. 2262.—BANDAGE OF SHOULDER AND ARM (DESAULT).
Second roller

an ascending spiral till the top of the axilla is reached; thence it is passed over the sound shoulder, under the axilla, and thence across the chest to be made fast (Fig. 2261).

The arm is then pressed against the axillary side of the chest, and the forearm placed horizontally across the front of the trunk. The second bandage is begun at the lower part of the arm and passed horizontally round the chest, including the arm, and ascending spirally to the axillæ. This holds the arm fixed to the side of the chest (Fig. 2262).

The third roller is begun in the axilla of the sound side; it passes obliquely across the front of the chest, over the clavicle of the diseased side, to the back of the shoulder, thence down the back of the arm, under the elbow, obliquely inward and upward across the forearm to the axilla of the sound side. Thence it passes under the axilla, obliquely across the back to the shoulder, crosses over the clavicle, down in front of the arm to the elbow, over this to the back, and obliquely across the back to the axilla of the sound side; this course is followed until three layers of bandage overlie. The last turn that passes forward across the shoulder, instead of passing down to the

FIG. 2263.—BANDAGE OF SHOULDER AND ARM (DESAULT).
Third roller.

elbow, should pass around the wrist, and the end should be carried back over the sound shoulder and made fast behind the back (Fig. 2263). At the places where the layers cross, the bandages should be pinned or sewed together.

This bandage is used to immobilize the shoulder joint, and in the treatment of fractures of the clavicle.

Upper arm fixation bandage is applied with a roller 6.5 cm. (2½ inches) wide and 6 meters long. A pad of absorbent gauze or cotton cloth should be placed at the side of the chest and the arm pressed against it. The bandage begins at the spine at the level of the elbow, passes around the chest and arm, ascending spirally from the elbow to the axilla. When the sound axilla is reached, the bandage passes thence across the shoulder of the diseased side down in front of the axilla to the lower border of the bandage, back between the elbow and the chest, upward to the shoulder, forward across the shoulder, and thence obliquely downward across the front of the chest to the sound axilla where it is made fast (Fig. 2264).

FIG. 2264.—UPPER ARM FIXATION BANDAGE.

FIG 2265.—UPPER ARM FIXATION BANDAGE WITH SUPPORT OF FOREARM.

This bandage is useful in holding the arm to the chest wall in cases of disease or injury of the shoulder or upper arm. It allows the forearm to be free. If it is desired to restrain the forearm this may be done by carrying

FIG. 2266.—MOBILIZING BANDAGE OF THE ELBOW.

the final oblique turn down around the wrist over the shoulder and making it fast to the back of the bandage (Fig. 2265).

Mobilizing bandage of the elbow is made with a roller 5 cm. (2 inches) wide and 4 meters long. It is begun a short distance below the elbow where

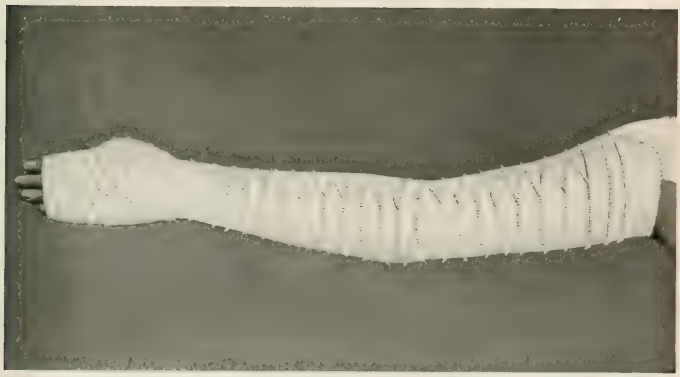


FIG. 2267.—BANDAGE OF UPPER EXTREMITY.

two or three turns are made to hold the end, the elbow being slightly flexed. The bandage is then carried obliquely upward across the joint and around

the upper arm a short distance above the elbow. A circular turn is carried around the arm once or twice. Thence the bandage descends obliquely across the front of the elbow, and around the forearm, covering two-thirds of the underlying bandage. It passes around the forearm, and thence back across the front of the joint to pass again around the upper arm. Each turn around the arm and forearm passes closer and closer to the elbow. The posterior aspect of the elbow is left uncovered to the last, and is finally covered as the edges of the approaching bandages convene (Fig. 2266).

This bandage permits motion of the elbow. It is used to retain dressings and as a part of an ascending bandage of the whole extremity. It may be combined below and above with a spiral or spica bandage.

Bandage of the upper extremity, for covering the hand, forearm and arm, is made with a roller 5 or 6.5 cm. (2 or $2\frac{1}{2}$ inches) wide and 6 meters long. It is begun by making two turns around the wrist. Then it is carried ob-

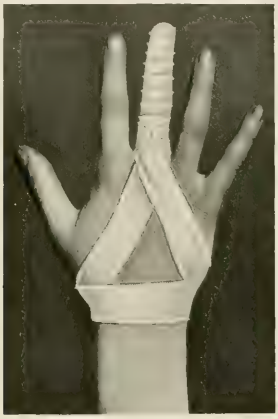


Fig. 2268.—Spiral Bandage of Finger.

liquely across the back of the hand and once around the fingers; thence it ascends crossing the descending turn at the back of the hand and passes around the wrist. Ascending and descending turns are made until the hand is covered. Then the bandage ascends the forearm as a spiral reverse. At the elbow it may be converted into a bandage which permits motion. The upper arm is covered by a spiral reverse (Fig. 2267). If desired the bandage may be continued as a shoulder spica.

If a splint or a dressing is applied to the whole upper extremity and motion at the elbow is not desired, a continuous spiral reversed bandage may be applied.

Spiral bandage of the fingers is applied with a roller 2.5 cm. (1 inch) wide and 2 meters long. The beginning is secured by two or three turns around the wrist. The bandage then passes obliquely downward across the back of the hand to the finger. The finger is covered by descending spirals from the base to the tip. A turn is taken around the tip, and then an ascending spiral carried upward. At the base of the finger the bandage passes

obliquely across the back of the hand to the wrist. Two or three turns are made around the wrist to hold the ends (Fig. 2268).

This bandage is used to retain dressings or splints.

Glove bandage of the fingers and hand is applied with a roller 2.5 cm. (1 inch) wide and 3 meters long. It begins with two circular turns around the wrist. It is then carried to the tip of the thumb by an oblique turn, and the thumb is covered from below upward by an ascending spiral or spiral reverse bandage. The bandage then passes to the wrist where a circular turn is made. Thence it descends by an oblique turn to the tip of the index finger. This finger is covered the same as the thumb and a turn made around the wrist. Each finger is successively covered in this manner. At the end a few turns are made around the wrist (Fig. 2269).

FIG. 2269.—GLOVE BANDAGE OF FINGERS.

This bandage is used to retain dressings and splints.

Spica bandage of the thumb is applied with a roller 2.5 cm. (1 inch) wide and 3 meters long. It begins with two turns around the wrist. Thence an oblique turn descends to the end of the thumb, where two circular turns are made. Then an oblique turn ascends across the back of the thumb to the wrist, around the wrist and obliquely downward to the end of the thumb, around the thumb and obliquely upward to the wrist. Each turn covers two-thirds of the preceding turn. Thus an ascending, woven effect is secured. The final end is carried around the wrist (Fig. 2270).

This bandage is used to retain dressings or splints or to immobilize the joints of the thumb.

Bandage of the hand, covers either the front or back of the hand and is made to embrace the roots of the fingers. Two circular turns are made around the wrist. The bandage is then carried around the root of the little finger and then back to the wrist. A turn is taken around the wrist and then the bandage passes around the next finger. This is continued, the last turns being taken about the thumb and then the wrist. After passing about

the fingers the bandage returns to the wrist across the palm or dorsum, whichever requires to be covered (Fig. 2271).

Fig. 2270.—Woven Bandage of Thumb.

Fig. 2271.—Bandage of Hand.

Complete bandage of finger covers the whole digit. A roller 1.25 cm. (½ inch) wide and 1 meter long is used. A few circular turns around the middle of the finger are first made. Then a reverse at 45 degrees on the dor-

sum is made, and the bandage carried over the end of the finger to the palmar surface. It is here, doubled back upon itself, and carried again over the end of the finger. Thus it is carried back and forth across the end of the

FIG. 2272.—COMPLETE BANDAGE OF FINGER.

FIG. 2273.—SPIRAL BANDAGE OF THE CHEST.

finger, each time passing further away from the middle. Finally, the end covering is complete and the folds pass to the side. Then the bandage is continued as an ascending spiral reverse bandage. While the end covering is being applied the folds at the place of reversing are held firmly by the

FIG. 2274.—SPIRAL BANDAGE OF THE CHEST WITH FIXATION STRAPS.

FIG. 2275.—POSTERIOR FIGURE-OF-EIGHT BANDAGE OF THE CHEST.

surgeon's fingers. The bandage ends at the root of the finger where it is pinned, tied or fixed with adhesive plaster (Fig. 2272).

FIG. 2276.—SINGLE COMPRESSION BANDAGE OF BREAST.

FIG. 2277.—ASCENDING SPIRAL BANDAGE OF THE BREAST.

Bandages of the Trunk.—*Special bandage of the chest* is made with a roller 7.5 cm. (3 inches) wide and 8 meters long. It begins with circular turns around the lower part of the chest. The bandage then ascends, each turn

covering about half of its predecessor. When the axilla is reached the bandage passes under it obliquely across the back to the opposite shoulder, forward and obliquely down the front of the chest. At the bottom it is fastened and folded back, passing over the other shoulder and fixed behind (Figs. 2273 and 2274).

This bandage holds dressings to the chest, and may be used to immobilize broken ribs. It should not be too tight lest it seriously interfere with respiration. The shoulder straps prevent downward displacement.

Anterior figure-of-eight bandage of the chest is made with a roller 6.5 cm. (2½ inches) wide and 6 meters long. It is begun at the axilla. The bandage passes obliquely across the front of the chest, over shoulder, under the axilla, obliquely across the front of the chest, over the other shoulder, under the other axilla and so on, repeating its course. Each turn should pass a little higher than its predecessor, for which reason the first turns should pass as

FIG. 2278.—DOUBLE SUPPORTING BANDAGE OF THE BREASTS.

low as possible. The bandage is continued till the neck is reached (Fig. 2238).

This bandage is used to hold dressings to the front of the chest, and to hold the shoulders forward.

Posterior figure-of-eight bandage of the chest is made the same as the above except that it is applied to the back of the chest. Instead of ascending decussations the crosses descend as they are applied (Fig. 2275).

This bandage is used to hold dressings to the back and to draw the shoulders backward.

Single compression bandage of the breast is made with a roller 6.5 cm. (2½ inches) wide and 6 meters long. It is begun at the bottom of the scapula on the affected side and passes over the shoulder across the breast, below the axilla and back to the place of beginning. Then the bandage passes horizontally around the chest just below the breast, to the axillary line, obliquely

across the back, over the shoulder, down across the breast, and around the chest. Each turn around the chest passes a little higher and each oblique anterior turn passes a little further toward the axilla of the diseased side (Fig. 2276). This makes a line of weaving just below the breast. An ascending spiral of the breast is useful for larger mammæ (Fig. 2277).

This bandage is used to support and compress the breast and to hold dressings.

Double compression bandage of the breasts requires two rollers each 6.5 cm. (2½ inches) wide and 6 meters long. The bandage is begun as the above at the lower angle of the right scapula. It passes upward across the back to the left shoulder, down across the lower part of the right breast, horizontally across the back, across the lower part of the left breast, over the right shoulder, downward across the back, horizontally under both breasts, diagonally across the back to the left shoulder, down across the right breast

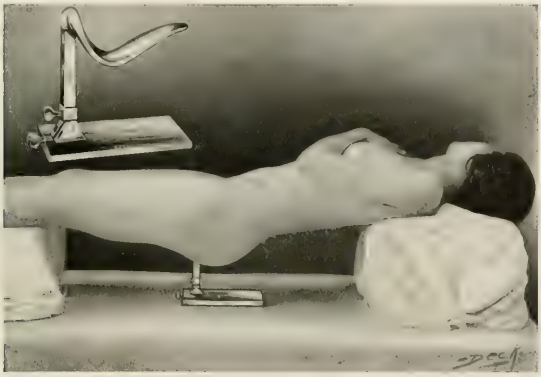


FIG. 2279.—PELVIC REST FOR SUPPORTING THE PELVIS WHILE BANDAGES ARE APPLIED.

and again to the back. Thus the bandage should make a cross on the back and front of the chest and a transverse layer around the waist, each turn should be a little higher than the preceding one. About two-thirds of each turn should be covered by the following layer (Fig. 2278).

This bandage is used to support and compress both breasts and to hold dressings.

Support of Pelvis.—While bandaging the pelvis, groins and thigh, the pelvis must be supported. The rest (Fig. 2279) made for that special purpose serves best. If such a thing is not available, a sand-bag, a metal wash-basin, or the doubled fists of an assistant serve the purpose.

Bandages of the Lower Extremities.—*Ascending spica bandage of the groin* is applied with a roller 7.5 cm. (3 inches) wide and 6 meters long. It is begun by placing the end of the bandage on the front of the abdomen just above the groin. The bandage is then carried downward and outward around the outer side, back and inner side of the thigh, passing forward to the groin about the width of a bandage lower than the perineum. Thence it passes obliquely to the outer side of the pelvis, across the loin, over the opposite iliac crest and down around the thigh again. Each turn covers

two-thirds of the preceding turn at the groin. A few safety pins catch the folds (Fig. 2239). If it is desired to make the bandage especially tight the thigh should be flexed slightly while it is being applied.

This bandage is used to hold dressings on the groin, upper thigh and lower abdomen, to make pressure, to retain inguinal and femoral hernia, and as a transition between bandage of the thigh and trunk.

Descending spica of the groin is begun the same as the above excepting that the initial end is placed higher. The first turn of the bandage is the highest. Each succeeding turn passes lower. The upper third of each turn is left uncovered by the recurring turns (Fig. 2280).

FIG. 2280.—DESCENDING SPICA BANDAGE OF GROIN.

The bandage is used for the same purposes as the ascending spica. The ascending bandage is most used.

Thigh bandage with spica of groin is applied with a 7.5 cm. (3-inch) roller. A few transverse circular turns are made below and then the bandage ascends as a spiral reverse up to the place below the groin where a spica begins. The bandage is then continued as a spica of the groin. The lines of obliquity should be parallel and the places of crossing in an even line (Fig. 2281).

This bandage is used to retain dressings and is the form used in applying immobilizing bandages to the thigh.

Spica bandage of the buttock is made with a roller 7.5 cm. (3 inches) wide and 6 meters long. It is similar to the spica of the groin except that the cross weaving is posteriorly. It is begun at the back of the thigh just below the gluteal fold, and is carried around the upper part of the thigh to fix the initial end, up across the sacrum, around the pelvis, and then back to the

upper posterior part of the thigh. These turns are repeated, each one passing a little higher than the preceding one. After four or five oblique turns have been taken, two or three horizontal turns are made around the upper part of the pelvis (Fig. 2282).

This bandage is used to hold dressings on the buttock and upper posterior part of the thigh.

Bandage of the thigh is best made in the form of an ascending spiral reverse (Fig. 2237). If it is not continued above as a spica of the groin, it may be prevented from slipping down by fixing its upper border to the skin with adhesive plaster.

FIG. 2281.—THIGH BANDAGE AND SPICA OF GROIN.

Mobilizing bandage of knee is applied the same as that of the elbow. A 6.25 or 7.5-cm. (2½ or 3-inch) roller is used. It is begun at the upper part of the lower third of the thigh where a few circular turns are made. Then it passes obliquely across the condyle and the popliteal space and horizontally twice around the leg just below the patellar tubercle of the tibia. Thence it passes back to the thigh, crossing the descending bandage at the popliteal space. It passes around the thigh, and returns to the leg by crossing the popliteal space. Thus the bandage encircles the limb alternately above and below the knee. Each time it is carried around the leg it passes close to the knee, each turn covering about two-thirds of the preceding turn. The popliteal space is covered but the front of the knee

remains exposed until the last. Finally the two edges come together in front of the patella but should not overlap (Fig. 2283).

This bandage permits bending the knee. It is used to hold dressings and for purposes of pressure.

Adducting immobilizing bandage of the knees is made with a 6.5-cm. (2½-inch) roller. A pad of gauze is placed between the knees so that skin does not lie in contact with skin. The bandage is begun below the knees,

Fig. 2282.—Spica of Buttock.

where two circular turns are carried around both legs. The bandage then ascends and descends as it passes around both legs, each turn covering two-thirds of the preceding. The line of cross weaving should be anteriorly in the median line. When the bandage reaches the middle third of the thigh the end should be brought between the limbs and a vertical turn made between the limbs, thus bandaging the bandage. This last turn prevents displacement of the bandage (Fig. 2284).

FIG. 2283.—MOBILIZING BANDAGE OF KNEE.

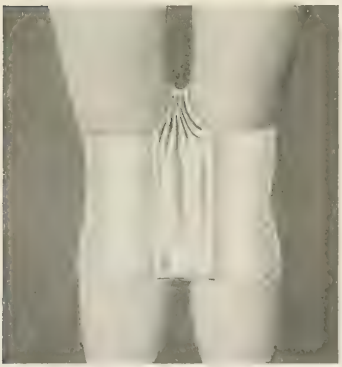


FIG. 2284.—ABDUCTING IMMOBILIZING BANDAGE OF KNEES.

This bandage is used to hold the thighs in adduction in disease and injury of the perineum and pelvis, to retain dressings, and to immobilize the thigh in disease and injury of the hip.

Bandage of the leg is best applied in the form of a combined ascending spiral reversed bandage and simple ascending spica. From the ankle to the

Fig. 2284*a*.—Bandage of the Foot and Leg.
Showing bandage of tricot or flannel applied for the purpose of making even pressure. Such a bandage is used in cases of edema or varicose veins.

middle of the leg a spiral reverse is applied. Then a sweeping turn is made above the calf and the bandage carried back to continue the turns parallel with those of the spiral reverse. This weaving spica makes no reverses and continues as far as the head of the tibia.

Fig. 2285.—Spica of Foot and Ankle.

Fig. 2286.—Bandage of Foot and Ankle with Reverse Covering of Heel

This is a much used bandage. It is effective and should be beautiful. It is employed to retain dressings and splints, and to make compression in cases of varicose veins and edema.

The bandage of the leg may be combined with a bandage of the foot and of the thigh. All may be made continuous in one bandage. This is the bandage used in applying the superficial layers of the plaster-of-Paris case for immobilization. When applied for the purpose of making even compression to control edema or to give support to varicose veins, flannel or tricot is to be preferred to cotton fabric. When these softer and more elastic materials are used the layers of bandage need not overlay more than one-half of the preceding turns (Fig. 2284*a*).

Fig. 2287.—Spica of Foot and Ankle Exposing Heel.

Spica of the foot and ankle is made with a roller 5 or 6.25 cm. (2 or 2½ inches) wide. Two circular turns are carried around the foot just above the toes. Then the bandage ascends obliquely and passes around the heel, the lower border being on a level with the sole. It returns to the dorsum of the foot, crosses the ascending turn, and again passes below the sole. Thence it ascends, passes behind the ankle, and returns across the dorsum of the foot. It should continue in this way, weaving across the dorsum of the foot a uniform series of turns, each one covering two-thirds of the preceding turn. When the foot and heel have been covered, the bandage may end or

it may be continued as an ascending spiral reverse bandage of the leg (Fig. 2285).

This bandage is used to hold dressings but especially to immobilize and compress the foot and ankle. It is the bandage that is used in sprains of the ankle. It should be uniform, smooth and beautiful.

Spica of the foot and ankle with covering of heel is applied the same as the above, excepting that a special turn is taken about the heel. As the bandage ascends from the foot one or two turns are made about the heel in such a way that the bandage is reversed in its course and returns across the same side toward which it approached the heel (Fig. 2286). Having covered the heel in this way the bandage may continue as that above.

FIG. 2288.—CAPITELLUM BANDAGE OF TOES.

Spica of foot and ankle exposing heel is begun as a spica of foot and ankle. The first ascending turn, instead of passing low around the heel, passes above the heel and thence back to the foot. In other respects it is the same as the ordinary spica (Fig. 2287).

Bandage of toes may be applied the same as a bandage of the fingers. It may be a simple spiral bandage, a spica, or a complete bandage.

If several toes require to be covered or the dressings must be large a complete capitellum bandage is indicated. Such a bandage is applied with a 4 or 5-cm. (1½ or 2-inch) roller. It is begun by making two or three turns about the middle of the foot. Then a reverse at a right angle is carried down across the middle of the dressing from the dorsum to the sole. This is then reversed back and forth first to one side and then to the other side of the first recurrent bandage as a capitellum, until the part is covered. Then it

ascends around the ankle as a spica. Unless it is carried around the ankle it will slip off of the toes. If much dressing is used the recurrent turns should not end at the middle of the foot but should pass around the ankle and thence over the ends of the toes. This insures security (Fig. 2288).

FIG. 2289.—EYE BANDAGE.

Bandage of amputated stump is the same as the complete bandage of a finger or the capitellum bandage of the toes. It begins with a few circular turns to hold the dressing; then the end is covered by the recurrent bandage; and this is continued as an ascending spica or spiral reverse (Fig. 2241). If the stump is of the upper arm or upper thigh, the bandage should continue

FIG. 2290.—FOUR-TAILED EYE BANDAGE.
Front view.

as a spica of the shoulder or groin. If it is not continued as such a spica a strip of adhesive plaster should be used to prevent slipping down.

Bandage of the penis may be a simple ascending spiral or better, a spiral reverse. A roller 2 cm. (¾ inch) wide is used. It should begin with two

circular turns near the root, then pass down to the end as an oblique spiral, then two circular turns should be made, and then it should ascend the penis as a spiral reverse (Fig. 2231). The end may be fastened by adhesive plaster, by a safety pin or by tying around the penis or around the penis and scrotum.

FIG. 2291.—FOUR-TAILED EYE BANDAGE.
Side view.

Bandage of the scrotum is made the same as a capitellum or recurrent bandage. The scrotum may also be supported by adhesive plaster (see Scrotum, page 304) or by a suspensory (page 778).

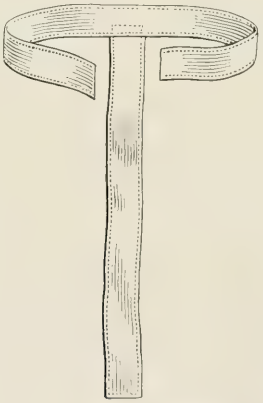


FIG. 2292.—T-BANDAGE.

Bandages of the eye have been described under bandages of the head. There are many special devices for covering the eye (see Eye, Vol. II, page 140). A useful eye covering may be made of a thick piece of cloth, cut in

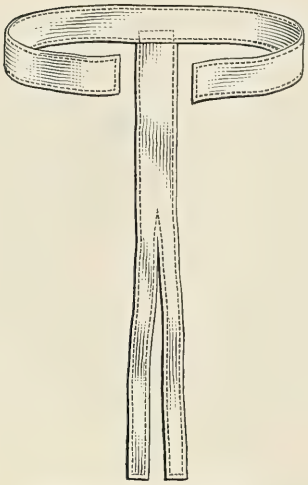


FIG. 2293.—DIVIDED T-BANDAGE.

FIG. 2294.—SUSPENSORY DIAPER BANDAGE OF SCROTUM.

the shape of a lozenge, 6.5 cm. (2½ inches) wide and 15 or 20 cm. (6 or inches) long, and having a tape sewed to either end (Fig. 2289). It may be applied horizontally to both eyes or obliquely to one eye. The tapes are carried around the head and tied on the forehead. By using tricot or

FIG. 2295.—SUSPENSORY BANDAGE OF SCROTUM.

flannel cloth a certain amount of elasticity is secured, which is of advantage in holding dressings.

Split bandage of the eye is made of a 6.5-cm. (2 ½-inch) muslin or gauze roller. A piece about 45 cm. (18 inches) long is used. This is split at both ends, having about 15 cm. (6 inches) unsplit. The unsplit part is placed

FIG. 2296.—SUSPENSORY BANDAGE OF SCROTUM COMPLETED.

obliquely in front of the affected eye; one tail of the split end passes above and the other below the ear; the tail passing under the ear is tied to a tail from the other side which has been brought around beneath the occiput; the two other tails are tied on top of the head to prevent the bandage slipping down.

This bandage is modified by G. A. Morley by making a hole for the ear in the unsplit part (Figs. 2290 and 2291) (for Bandages of the Eye see page 749).

The T-bandage may be made of varying widths and lengths of material. It consists of one piece of bandage sewed to another at a right angle (Figs.

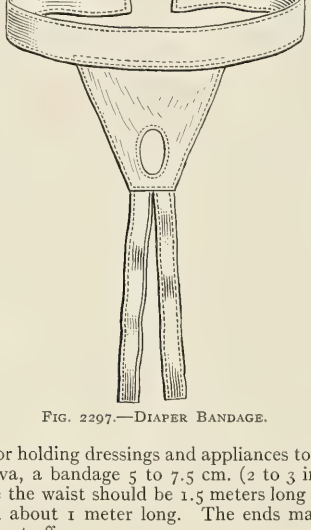


Fig. 2297.—Diaper Bandage.

2292 and 2293). For holding dressings and appliances to the perineal region, anus, groin, or vulva, a bandage 5 to 7.5 cm. (2 to 3 inches) wide is used. The part to encircle the waist should be 1.5 meters long and the part to pass under the perineum about 1 meter long. The ends may be tied in a bow knot or pinned and cut off.

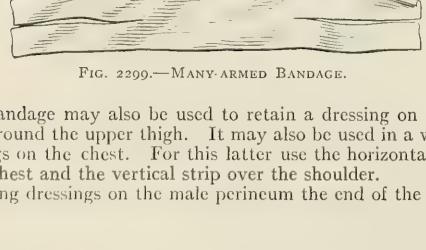


Fig. 2299.—Many-armed Bandage.

Such a bandage may also be used to retain a dressing on one groin by bringing it around the upper thigh. It may also be used in a wider form to hold dressings on the chest. For this latter use the horizontal strip passes around the chest and the vertical strip over the shoulder.

For holding dressings on the male perineum the end of the vertical strip

may be split to within 15 cm. (6 inches) of the waist-band. This allows one end to pass on either side of the external genitals. The **split T-bandage** may also be used on the chest. For this purpose the cross-piece is made

FIG. 2300.—MANY-ARMED BANDAGE APPLIED TO ABDOMEN.

FIG. 2301.—FOUR-ARMED CHIN BANDAGE.
Front view.

broad, and is applied horizontally around the chest. The two tails pass over the shoulders like suspenders.

Suspensory bandage of the scrotum may be made by fixing the ends of a

wide bandage to a waist-band at the anterior superior spines. This is carried under the scrotum, and the two sides pinned together on either side (Fig. 2294).

J. H. Cunningham devised a *hammock suspensory* made of cotton flannel. An oblong piece, 40 cm. (16 inches) long and 20 cm. (8 inches) wide, having a notch cut out of either end is used. A button-hole is cut in each corner. About the waist of the patient is placed a webbing belt having a button opposite each anterior superior iliac spine. Two corners of the suspensory are buttoned to the belt. The edge lies behind the scrotum (Fig. 2295). The two other ends are gathered up and buttoned to the belt. A hole is cut for the penis if desired (Fig. 2296).

Diaper bandage of the pelvis is made the same as the T-bandage except that the horizontal piece is made wider (Fig. 2297). Such a bandage may be applied with the broad piece behind, for holding dressings to the sacrum and perineum, or anteriorly for holding dressings to the pubic region. A hole may be cut in the diaper for the penis (Fig. 2298).

FIG. 2302.—FOUR-ARMED CHIN BANDAGE.
Rear view.

Many-armed bandage is made of a strip of muslin having many cuts at two opposite sides, leaving a number of bandages connected with it. For the abdomen such a bandage is made in the form of a binder (Fig. 2299). When it is applied the free ends are brought anteriorly, each end passing between two other ends. These ends are laid down one upon another, somewhat obliquely, thus forming an imbrication in which each holds the one it lies upon. The last tails may be pinned (Fig. 2300). In some cases it may be preferred to tie the ends in bows; or all of the pairs may be tied in a single knot, the ends being covered by the adjacent pair, until the last is reached, which is tied in a bow. A many-armed bandage may be useful in holding dressings to an extremity. Such a bandage allows exposure of the dressings without moving the limb.

Four-armed chin bandage is made with a strong piece of muslin 5 cm. (2 inches) wide and 1 meter (1 yard) long. A small piece is cut out of the center to make it fit the chin. The two ends are split lengthwise as far as an unsplit central part which should be about 7.5 cm. (3 inches) long. This central piece is placed on the chin. Two tails are carried to the occiput and tied, and two are tied over the top of the head far enough forward to tend

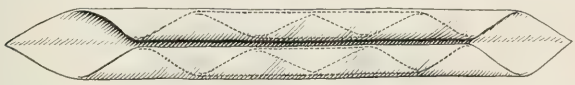


FIG. 2303.—HANDKERCHIEF OR CRAVAT BANDAGE FOLDED.

to slide anteriorly. The ends of the two ties are then separately tied at the back of the head (Figs. 2301 and 2302). This bandage is useful in immobilizing the lower jaw.

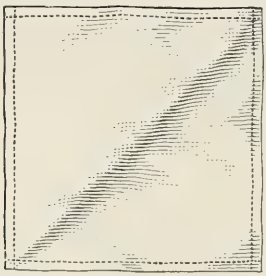


FIG. 2304.—HANDKERCHIEF BANDAGE.
This is a square of gauze or muslin the edges of which are hemmed.

THE HANDKERCHIEF BANDAGE

The square and triangular bandages have a wide range of uses. They may be employed to meet most of the requirements of the roller bandage

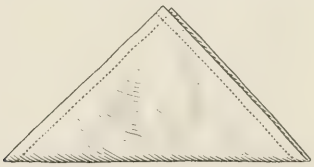


FIG. 2304*a*.—HANDKERCHIEF BANDAGE TO BE USED AS A SQUARE OR TRIANGLE.
Showing handkerchief folded once to make a triangle.

except that of compression. A square or triangular piece of muslin is used. It may be of any size. For some purposes it may be folded in the form of a cravat (Fig. 2303) which may be used for the purposes of a roller, and the ends tied or pinned together.

The triangle is described as having a base, apex, two sides and two base angles (Figs. 2304 and 2304*a*).

The simple occipitofrontal cravat passes over the forehead and occiput and may be tied at the most convenient place.

The **scalp cravat** may be made by placing a cravat of gauze over the scalp and holding it with several turns of a circular head bandage. As each

FIG. 2305.—SCALP CRAVAT APPLIED WITH ROLLER.

turn is made, the ends of the cravat are folded up and down beneath the bandage (Fig. 2305).

The **fronto-occipital triangle** is applied by placing the base across the neck below the occiput. The two sides are carried around the head. The apex

FIG. 2306.—SIMPLE OCCIPITOFRONTAL CRAVAT.

The base of the triangle is carried about the head and the two base angles tied together on the forehead over the apex. The apex is then folded upward and tied to the two base angles or pinned

is brought forward placed on the forehead and the base triangle ends tied over it. The apex is then turned up and pinned, or a second and third tie made, or a bow knot tied to hold it (Fig. 2306).

The **four-armed bandage of the head** is made of thin material like gauze. It should be about 1 meter (1 yard) long and 20 to 30 cm. (8 to 12 inches) wide. This should be split at both ends to within about 10 cm. (4 inches)

FIG 2307.—FOUR-ARMED BANDAGE OF THE HEAD.

FIG. 2308.—SCALP AND FACE CRAVAT

of the center. That leaves a piece 20 cm. (8 inches) long, having four tails This is placed on the head; the two anterior tails are tied under the occiput, and the two posterior tails under the chin (Fig. 2307).

The **scalp** and **face bandage** is made with a cravat which passes under the chin crosses at the top of the head, passes across the parietal regions, and is tied below the occiput (Fig. 2308).

FIG. 2309.—CRAVAT OF SCALP AND CHIN.

The **scalp** and **chin bandage** is a continuation of the above, crossing under the occiput and passing also in front of the chin. It may be tied behind, at the top of the head, or under the chin (Fig. 2309).

FIG. 2310.—FACE CRAVAT.

The **face cravat** is a simple broad band carried vertically around the head under the chin (Fig. 2310).

The **eye cravat** is a simple head bandage carried obliquely over the eye (Fig. 2311).

The **crossed-head cravat** is made by carrying the bandage across the forehead, parietal regions, under the chin, and occiput, in such a way that crossed loops engage at the sides of the head (Fig. 2312).

FIG. 2311.—EYE CRAVAT.

The **axillary cravat** passes under the axilla, crosses over the clavicle, and is tied in the opposite axilla (Fig. 2313).

FIG. 2312.—CROSSED HEAD CRAVAT.

Figure-of-eight cravat of chest is the same as the figure-of-eight bandage except that a cravat instead of a roller bandage is used (Fig. 2314).

Forearm cravat sling is a simple cravat passed across the back of the neck and forming a loop at the waist in front in which the forearm may lie.

Fig. 2313.—Axillary Cravat.

Fig. 2314.—Figure-of-eight Cravat of Chest.

FIG. 2315.—TRIANGULAR ARM SLING.

FIG. 2316.—TRIANGULAR SUSPENSORY BANDAGE OF BREAST.

Forearm triangular sling is made with a triangle formed by folding once a 1 meter (1 yard) square of muslin. One base angle should be placed over the sound shoulder, and the triangle should then be spread out on the

Fig. 2317.

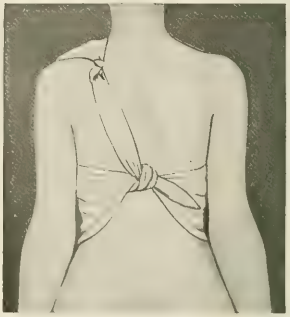


Fig. 2318.

Fig. 2317.—Triangular Bandage of Chest (Front View).
Fig. 2318.—Triangular Bandage of Chest (Rear View).

Fig. 2319.—Triangular Bandage of Shoulder.

chest behind the arm, the apex lying toward the axilla of the diseased side. The bandage is then carried about the flexed forearm and about the neck, the two angles being tied together at the side of the neck to support the

forearm in a horizontal position. The apex of the triangle is then brought around the arm and pinned in front, thus making a pocket for the elbow (Fig. 2315).

Triangular suspensory of the breast is made by placing the base of the triangular bandage below the breast and tying or pinning together the two angles, one being carried over the shoulder of the well side and the other under the axilla of the diseased side. The apex of the triangle is then carried over

FIG. 2320.—ILIOFEMORAL TRIANGULAR BANDAGE.

the shoulder above the breast and made fast to the two other angles back of the shoulder (Fig. 2316). This bandage is useful in supporting the heavy breast which is enlarged by lactation or inflammation

Triangular bandage of chest is applied by placing the base of the triangle about the waist and tying the two angles. The apex is carried over the shoulder and tied or pinned to the angles. This bandage may be applied to

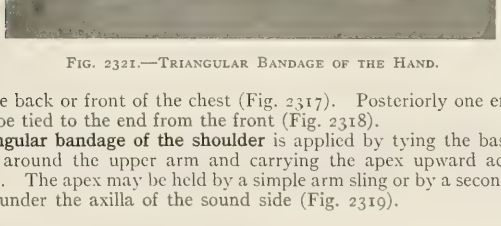


FIG. 2321.—TRIANGULAR BANDAGE OF THE HAND.

cover the back or front of the chest (Fig. 2317). Posteriorly one end is left long to be tied to the end from the front (Fig. 2318).

Triangular bandage of the shoulder is applied by tying the base of the triangle around the upper arm and carrying the apex upward across the shoulder. The apex may be held by a simple arm sling or by a second cravat passing under the axilla of the sound side (Fig. 2319).

Iliofemoral triangle is applied by placing the base of the triangle around the waist and tying the angles. The apex is allowed to fall at the side, thus covering the buttock, trochanteric region or groin. A folded cravat is carried around the upper part of the thigh and apex of the triangle. The apex is folded over this and fastened. The same regions may be covered by tying the base around the upper part of the thigh and fixing the apex of the triangle under a cravat around the waist (Fig. 2320).

Fig. 2322.—Triangular Bandage of the Foot

Triangular bandage of the hand is applied by carrying the base around the wrist 2 or 3 times, folding the apex over the hand and catching it under the base of the triangle at the wrist (Fig. 2321).

Triangular bandage of the foot is applied the same as that of the hand (Fig. 2322).

Triangular bandage of the knee is applied by placing the base below the knee and the apex on the front of the thigh. The base angles are brought

together in front after being carried twice around the leg. The apex is folded down under the base angles which are tied over it (Fig. 2323).

The **universal scarf** is a square of strong cotton cloth measuring 100 cm. (40 inches) across. It is folded obliquely to make a triangle. For immobilizing the upper arm, a pad of gauze is placed in the axilla, the elbow is brought close to the trunk, and the base of the triangular scarf is placed above the elbow, at the junction of the lower and middle thirds of the arm, the apex hanging downward. The scarf is drawn tightly around the body and the ends pinned together at the back. The middle of the base should be at about the xiphoid cartilage. The two hanging apices of the scarf should then be drawn up beneath the forearm, and one placed on each shoulder. A

FIG. 2323.—TRIANGULAR BANDAGE OF THE KNEE.

stout muslin bandage 8 cm. (3 inches) wide is pinned to each of these corners, drawn down and pinned to the base of the triangle as it crosses the back The layer of scarf in front of the forearm should be fixed with pins to the layer which passes behind. The hand may be placed in the gutter thus formed or left free.

This bandage is of service in immobilizing the upper arm, shoulder, elbow or forearm, and it is useful as a temporary dressing in fractures of the clavicle. It was devised by C. Marton.

Adhesive plaster has been described under Surgical Materials (Vol. I, page 55). As a bandage it has many uses. When applied to the skin, the hair should be shaved. If the skin has not been shaved benzin may be used to dissolve the adhesive material. It is of great value as an addendum to the muslin roller bandage. It may be used in place of pins to fix the ends and to prevent the layer of bandage from slipping (see page 738).

To Improvise a Roller Bandage from a Square.—It sometimes happens that a roller bandage is needed, but only a handkerchief or small square is available. W. H. Bailey (Jour. Am. Med. Assoc., Sept. 3, 1910) showed how a roller may be constructed of such material by cutting into it alternately

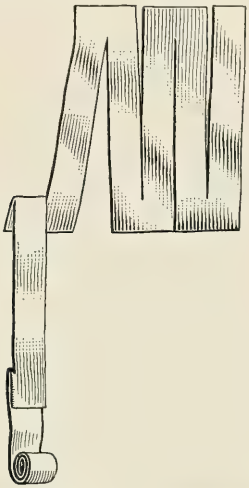


Fig. 2324.—Roller Bandage Improvised from a Square.

from opposite sides, making parallel strips of the desired width. Beginning at one end, the bandage is rolled; as the end of the strip is approached, it is folded at a right angle and then laterally onto the next strip (Fig. 2324). This is continued until the roller is completed.

Crepe Paper Bandages.—Bandages in the convenient widths from 2.5 cm. (1 inch) to 10 cm. (4 inches) are made of strong crepe paper. This material is light and cheap. The bandages may be used to retain dry dressings. They possess the elasticity which is a highly valuable quality in a bandage. When removed the waste material is easily disposed of. These bandages are to be recommended and are a valuable addition to surgical dressings. Towels and napkins are made of the same materials. For retaining larger dressings or dressings which may become moist a few turns of gauze bandages may be applied over the paper bandage.

THE ECONOMICS OF SURGICAL TREATMENT

Treatment is the object of all of the science of surgery. To know what to do is the ultimate aim of surgical knowledge. This art must always be connected intimately with the advancement of the whole science of medicine and hygiene. The medical sciences will always be associated closely with social progress. Society ever will demand a special class who shall study the problems of human health and to whom it may look for advice and help in these vital matters. It is aware that the possibilities for good inherent in this special knowledge are very great. The conquest of disease will become more important as life becomes more precious and better worth living.

There are four economic phases in which the practice of surgery may be viewed. The first is the competitive phase through which it is now passing. The others are surgery under the State, surgery under group experts, and surgery under coöperation. Surgical practice is destined to be moulded and modified by all of these.

SURGICAL PRACTICE UNDER COMPETITION

The practice of surgery, along with that of medicine, now approaches the end of its régime under ecomomic competition. At present most practitioners are still involved in the competitive struggle; as also are their patients. Most patients are poor. Although the medical sciences have made great progress, notably during the past half century, still the average patient receives but little of their benefits when the possibilities of what he might receive are considered.

The present competitive system has compelled the surgeon to be a business man, competing with his fellows for a livelihood. He must make so much money each year to support his family. This must be his primary concern. The more sickness and injuries there are, the longer patients are sick, the more operations he can do, just so much better does he seem to prosper in a competitive society. The practitioner who commercializes his manners as well as his knowledge and skill often has the largest practice and is publicly acclaimed as the most successful. It is well known, at least to the medical profession, that the surgeon who has the most knowledge, the greatest ability for his work, and the highest ideals in his devotion to it, often languishes for patronage because he does not bring to bear upon the public mind the spell which skillful advertising methods insure, or because he is unwilling to cater, in the interest of self-promotion, to the dominant authorities in hospital or college.

While these unfortunate circumstances of economic competition have prevented the development of surgeons and retarded the advancement of surgery, happily the forces of virtue are so great that there have come through it all, and risen to the top in their profession, thousands of splendid men and women, who possess superb talent, who represent high ideals, and who have carried forward the torch of learning often against great obstacles. The surgeon is the peer of the masters of every craft.

Among the obstacles against which the surgeon has had to struggle is not only the commercialization of his art, but also the distressing fact that

the ability of patients to pay is very poor. The people can not afford to employ a surgeon to do the best that possibly can be done for them. And in the average case the surgeon cannot afford to give the best possible thought and attention to both diagnosis and treatment.

The young man who has finished his hospital interneship, who is well-trained to enter practice, who has before him the vision of life, and who is filled with enthusiasm for the possibilities of helpful human service in his profession, is thrown into the maëlstrom of economic competition. Here he is confronted by the necessity to commercialize the sacred art of conserving human life. It is easy for him to fall into the habits of humdrum routine in a community which measures success by the standards of business. This is the pathos of medicine. We have no definite information as to whether the economic condition of the practitioner is worse or better than it was fifty years ago, but we do know two very important things: the capacity for useful service is infinitely increased, while the relative number of physicians during the past ten years is decreasing. What is, perhaps, still more significant, and surely most to be deplored, is the fact that the dividing of fees, the performing of abortions, the practice of unnecessary operations, and the resort to other expressions of commercialism are the expedients to which many a capable man of high-minded preferences is driven against his will, as a matter of economic necessity. There can be no more serious indictment against society than that it visits such dishonor upon those who are capable of great service.

The competitive system has made surgeons the trade antagonists of one another. It has denied to the surgeon the privilege of thinking only of perfecting himself in his art and doing the best possible thing for each patient who comes to his hands. It has compelled him to make these things secondary to earning a livelihood and to presenting the evidences of prosperity. Too often it has starved the man who devoted himself too zealously to his art and too little to his business. Happily, notorious exceptions are many, of surgeons who have seemed always to represent the highest ideals of their calling and yet who have thriven financially. Still, whatever may come, the surgeon should keep before him the thought that he is the disciple of a great art and the bearer of precious knowledge, that this is so potent for human good that it must not be prostituted to the levels of barter and trade, that he should give of his skill fully and freely, and hope that the material recompenses will be adequate to his needs. The moral satisfactions in the administration of surgical treatment are beyond price.

SURGICAL PRACTICE UNDER THE STATE

Surgical knowledge has been won through the sufferings of countless generations. Students of science, long since passed away, have contributed to it. Ancestors of all of us have died to give it to us. It is natural to think of it as social knowledge, the heritage of all, to be denied to none, its benefits to be accessible freely to the descendants of men, all of whom in due time may be called upon to contribute their quota to it. Certain great necessities, such as water, air and sunshine, society has come to believe should be accessible to all. Water should not be denied those who are thirsty, no matter what may be their economic status. The ethical awakening which is permeating the world is classifying all of the great human needs as social possessions, and demanding that their benefits shall be denied to none. There is also a growing sentiment that the evils, which spring from the competitive economic system, shall not be carried on into the future.

In all progressive communities a steady socialization of the public necessities has been in progress for many years. No longer do wise people leave to commercial enterprise such important matters as the supplying of water for the people, the disposal of sewage, the cleaning of the streets, the carrying of the mails, the extinguishing of fires, and the policing of cities. Public schools, libraries, recreations, parks, hospitals, and highways are indices of the communizing trend. There is practically no great human necessity but that somewhere in the world it is being administered socially for the benefit of the people. In great emergencies and in circumstances of stress, such as in time of war, this must be done in the interest of efficiency.

This trend is removing the sanitarian, the physician, and the surgeon from the field of private and competitive business, and bringing them closer to the needs of the people. In Europe, before the war, socialized medicine was rapidly being put into operation; and since the war its application has been still more rapid. The surgeon is becoming a public servant, subsidized by the state.

Contagious diseases have long been recognized as the concern of all the people, and they have been so treated. Society has been much concerned also for mental diseases. It took cognizance of the insane because of their irresponsibility; and then because of their relations to the problems of heredity it became concerned for all with transmissible mental defects. In response to this same social psychology, all other diseases and injuries are becoming matters of public concern, because, even though they may not spread from sick individuals, still they have their origin in food, housing, occupation, industry or other conditions which are matters of public concern. Because of the increasing closeness of our human relations and our interdependability on one another, any condition which society harbors, capable of producing disease or injury, is coming to be recognized as the concern of all. Therefore if society is interested lest it may suffer from disease in an individual, equally so is society becoming concerned that the sufferers with surgical diseases be healed and that cripples be restored to efficiency. The new morality demands that this shall no longer be left to the fortuitous circumstances of wealth or to the ability of the individual to purchase healing.

Increasing public activities are demanding physicians and sanitarians, and along with these goes the surgeon. The education of men and women for this work is destined to come into the hands of the people. Medical education in America has passed through its first stage, that of private commercial enterprise; and it is now well advanced in its second stage, that of regulation and control by the state. The third is that in which it becomes wholly a public function; and already we have many public medical schools in which the people are educating their own surgeons. Surgery is no longer a private affair of the surgeon, it is rapidly becoming a matter of general social interest and economic concern.

The socialization of surgery means the employment of the surgeon by society as a whole, by the state or by the political government. With adequate salary, insurance, and a pension for his old age, he should be free to perfect his art. The socialized surgeon is seen in the armies, navies, and in governmental and municipal hospitals. He is not working under pure socialistic conditions, however, until all necessities which surround him are socialized. As the activities of the state become more embracing, socialized surgery will become more perfected and purified. When the surgeon's living and the necessities for happiness are guaranteed by society, he will find still added happiness in performing useful service for the society which is performing useful service for him.

SURGICAL PRACTICE UNDER GROUP EXPERTS

Syndicalism means organization of the producers at the point of production to control their industry or the output of their craft. In medicine it represents the guild principle. In a field so highly specialized as surgery we are dealing with group experts. The principle is that of the syndicate or guild.

An example of the principle of group experts in surgery is the Mayo Clinic at Rochester, Minnesota. Here is a group of surgeons and physicians who control a great organization for producing surgical and medical treatment. The income from services accrues to the members of the group, who vote to distribute it as they please. Economic competition among them is eliminated. The possibilities of a high grade of scientific work are greater under such a régime than under competitive individualistic methods. This is because it represents coöperation at the point of supply, at the place where the things are done. In such an organization financial success may be so great that the economic side of the work may be made secondary to the scientific side. And this is precisely what happens here. This organization can afford to render absolutely the best possible service impartially to rich and poor alike, the total income guaranteeing such a policy. Whatever may be said of the high class of scientific treatment provided at the Mayo Clinic, by far the most important thing to be seen at this extraordinary center is the social demonstration. Here is an object lesson in organization capable of application to every branch of medical practice and susceptible of adoption by the whole medical profession, provided it were more fully democratized. Such a syndicalized enterprise may become absorbed by the collective state, or amalgamated with the coöperative movement. Already the indications are that this institution will become absorbed ultimately by the state while its administration will remain in the control of the workers. This is infinitely better than that it should be taken over wholly by the state. The workers in a profession or industry should always desire to save their craft from falling under the absolute domination of the political state.

It would be entirely possible for a central body, such as the American Medical Association, to proceed to develop the medical profession in this country as a great organized group of experts, guaranteeing to each member an adequate income, demanding high standards of efficiency, seeing to it that the man is adapted to the specialty and the specialty to the man, ultimately publishing its own books and journals, subsidizing its own authors, manufacturing its own instruments and medicines, and conducting its own colleges and hospitals. Thus would be harmonized the now scattered elements which enter into medical practice.

The American College of Surgeons is already organizing surgical practice in this country in response to this guild principle. This body is capable of serving as the nucleus out of which may grow the coördination of surgery and surgeons, and which may coöperate with other medical groups in the working out of this problem. It is quite possible that it should become an economic force as well as a moral and educational influence.

Such an organization would require to be upon an absolutely democratic basis. It should not be modeled after the political state nor after any great association dominated by autocratic methods. One member one vote, the recall, the initiative, the referendum, preferential ballot, absolute publicity, and organization which should be amenable to the will of the membership are some of the imperative requisites for success. A great central

organization is not necessary; such a syndicalization of medicine could be brought about by the sporadic development of local medical groups or syndicates and their gradual coalescence. Many such groups are now developing. What their destiny may be, no one can foretell. One thing is certain: unless the medical profession thus organizes itself, it will either be confiscated by the state, and socialized, as has transpired in England; or the best employment will be found in the large, voluntary groups, as is coming to pass in the sickness societies, and in the great consumers' societies found in all the European countries. We are living in a period of precipitous social change; and it is the part of wisdom to face the new issues that are so rapidly developing.

In Great Britain, France and Italy the dominant tendency more recently is toward a combination of government ownership and syndicalism, called guild-socialism. That is a condition in which the State owns the industries but the workers control them. Thus, in surgery, that means that the government would own the hospitals but the doctors would govern them. The State would have jurisdiction over social property, but the workers themselves would control their own lives and conditions of work. This problem has been carefully thought out. Its tendency is to stabilize property and liberate industry. It is destined to play an important part in the development of surgical treatment in the near future.

SURGICAL PRACTICE UNDER COÖPERATION

The Coöperative Movement begins with groups of people organizing themselves into consumers' societies, working together for their common good to secure better access to the necessities and luxuries of life. Its aim is that the people shall administer for themselves to satisfy their own wants, instead of that these wants should be supplied by private business; that the people shall be their own storekeepers, wholesalers, manufacturers, bankers, and insurance companies; and ultimately that the people shall administer the social affairs which are now administered by the political state. Among these necessities is surgical treatment.

This is all rapidly coming to pass. These consumers' societies own their own hospitals and sanatoriums, and employ physicians and surgeons upon a salary basis. In every major European country, excepting Turkey, at least one-fourth of the population is embraced in the Coöperative Movement; in Denmark it includes over two-thirds of the people; and in Russia the movement now embraces more than one-half of the population. The Russian zemstvos, or local representative assemblies, have for many years been organizing hospitals and providing medical and surgical care for the people, independent of the national government.

The relation of the surgeon to this worldwide Coöperative Movement possesses great possibilities. In the European countries in which the coöperative societies are organizing their own hospitals and sanatoriums the surgical side of the experience has proved most successful. These societies have already demonstrated on a large scale the possibilities of the people themselves, independent of the state or private business, providing their own sickness insurance, mothers' subsidies, and pensions. They have successfully moved into the field of medical and surgical treatment. This is a most striking demonstration of the possibilities of voluntary group action. They have long ago passed national bounds and are now the greatest coördinated international economic force in existence, representing over 200,000,000 people.

The old and imperfect "sick benefit society," the "krankenkassen," the "coöperative clinic," and the sickness insurance societies in schools and colleges, are imperfect efforts of coöperation to make use of medicine. The great and virile coöperative movement which for the forty years before the war showed a yearly increase in Europe 5 times faster than the population, and which during the war increased 10 times faster than the population, does not organize the care of the sick and injured as a special enterprise but connects it with the whole movement for the social and economic welfare of the members, and thus guarantees its success. How far these organizations will go toward employing the surgeon, can not be predicted. They are moving in the same direction as the socialized state—toward the coöperative commonwealth.

THE ULTIMATE NEEDS AND DESTINY OF SURGERY

The ultimate need of surgery, in order that it may attain its best form of expression, is that it shall be free. The surgeon, to do the best possible thing for the surgical patient, must be liberated from economic trammels. The practice of a great art can not be reduced to terms of barter. Freedom and coöperation are essential.

Of the three fields in which the destiny of surgery is to be worked out—that under the state, under group experts, and under coöperation—it is to be hoped that ultimately that under coöperation, with a large element of guild control added to it, shall dominate. The surgeon's dream of the future should be a free society of people, administering their own affairs, organized into groups of specialists, each doing its unhampered work. All three of these are destined to play an important rôle in the reorganization of society. Indeed, there is no reason why the competitive surgeon may not also continue as a factor; but he is destined to find himself isolated and alone. If he actually possesses great talent which seems capable of producing much profit for himself, he will find that the state or the coöperative society will develop some one who can equal him in skill, or the state will confiscate him and compel him to socialize his service, or the surgical syndicate will show him that his best interests can be served by working with his fellow surgeons, or the coöperative society will pay him more than he could earn in competitive practice.

A primary need in the development of surgery is the separation of the agencies of diagnosis and treatment. The practice of surgery has become complicated. It is related to all of the branches of medicine. The surgeon must now be something more than a surgeon, would he be the master of his art. The time has come when no man can command the whole subject in its range of pathology, symptomatology, diagnosis, prophylaxis and treatment. Correct diagnosis is a prerequisite for efficiency in surgical treatment. But so many additions to our knowledge of diseases and the technic of their diagnosis have developed in the past twenty-five years that the diagnosis of surgical ailments has passed beyond the abilities of any one individual. Much less can perfected diagnostic skill be combined with therapy.

For the best results in diagnosis alone team work is now required. The surgeon who is most competent to operate upon the multitude of surgical lesions of the trunk or cranium is not the person who can best diagnose the lesions which he is most qualified to cure. Before the true nature of a surgical malady can be discovered, there must often be invoked the aid of the *x*-ray, blood examinations, serum tests, bacteriologic studies, nerve tests, ocular examinations, and investigations of cerebrospinal fluid. These are not all within the field of any single individual; nor are they all a part of the equipment of the therapist.

It is not necessary that diagnosis be followed at once by treatment. It may be deferred, or no treatment may be desired or indicated. The patient with an accurate knowledge of his disease may make such use of that knowledge as he sees fit. The disease is his. He naturally should want the best possible information concerning its location and nature. His medical advisor with this information is in a position to tell the patient where he may go for the best surgical treatment. The natural step would be to go with the accurate diagnosis to the surgical therapist with the view of having the disease cured.

Under the circumstances of the present competitive régime, unfortunately the patient with symptoms which distress him does not first bethink himself of diagnosis as a separate thing, neither does his family physician. The patient is sent to the surgeon who is selected for his ability to treat conditions which have symptoms that approximate the symptoms with which the patient suffers. The surgical therapist undertakes the functions of the diagnostician; but inasmuch as he can not master all things we find the surgeon who attempts to combine the diagnostician with the therapist falling short of the possibilities of each. The surgeon usually goes ahead and finds enough diagnostic signs to justify him in his own mind in proceeding to follow some specific procedure of treatment.

This method has been outgrown by modern surgery. The surgeon diagnostician-therapist is an anachronism. He should functionate only as an emergency expedient. The reproach of surgery has been that too often the wrong operation was done because the correct diagnosis was not made. The inexcusable result is seen in operations upon the vermiform appendix when the disease is stone in the ureter, appendectomy when the malady is pneumonia, hysterectomy when the condition is pregnancy, salvarsan injections for syphilis when the trouble is eczema, laryngectomy when the disease is syphilitic laryngitis, and gastro-enterostomy when the symptoms are the abdominal crises of spinal lues. In my experience I have known of all of these miscarriages of surgery, and many more.

Diagnosis should be regarded as a distinct branch of learning. Surgical diagnosis can not be separated from medical diagnosis. The speciality should be diagnosis; and the specialists should be a coördinated group of scientists, depending upon coöperation with each other for their efficiency. Diagnosis has long since ceased to be a one-man field.

The new society should provide institutions into which a patient may go, and where all of the technic and learning concerning diagnosis may be concentrated upon his case. There is available enough scientific knowledge to diagnose every ailment. Such an institution would coördinate all of these departments of learning. The radiologist, the gastro-enterologist, the serologist, the bacteriologist, the hematologist, the urologist, the ophthalmologist, the neurologist, and specialists in all of the other branches of diagnostic learning, coöperating to arrive at a diagnosis, represent an utterly different function from that of the individual surgeon making an examination with the hope or expectation of finding something to justify operation or other treatment.

The advantages of such an organization and such a method with which to precede surgical treatment are obvious. This is the practical, coöperative, social method. It is by no means an utopian dream, because the diagnostic hospital is already in operation in some parts of Europe. The Mayo Clinic in America applies precisely this principle. In mental diseases, this method has long been employed.

Such an organization is demanded in the interest of the sick. The diag-

nostic clinic need not be separated from the hospital where treatment is applied. The two may be adjacent or under the same roof. The diagnostician and the therapist need not be strangers. They should be freely in consultation with one another. Diagnosis may often be clarified by the light which the therapist can throw upon it; and the surgeon in his treatment may often be guided by the finer knowledge of the diagnostician. The important factors are that the agencies of diagnosis should be united and coöperative, and the surgical therapist should be relieved of responsibilities which the progress of science has carried beyond his sphere.

The destiny of surgical practice is intimately bound with that of all human progress. Society is organizing itself for more intensive group action, and isolated individualism seems to have run its course. As one looks into the future, communities are seen divided into sanitary districts, each with a sanitary expert answerable for the public health. Each district should have not only a social center but a sanitary center. Here should be laboratories for diagnosis, equipped with every appliance and facility of science, with experts in every department. In connection with it should be a central hospital. An out-patient and an in-patient department should supplement one another. This should be a community centre in which the problems of disease are worked out. Prevention should be the keynote, and this should supercede the old idea of making treatment the aim of medical effort. According to the needs of the people, specialists in all branches should be located at convenient intervals in dispensaries and hospitals. This should apply to country as well as town. The whole plan should be harmonized to the population, to the geography and to the transportation facilities.

The criminal court-house should become a diagnostic institution, and should be affiliated with the hospital system. The jail should be supplanted by a specialized hospital for the treatment, not the punishment, of those committed to its care.

Vocational selection of surgeons should be practised. It should not be left to chance what particular man shall attempt the responsibilities of surgery. The round pins should not be found in the square holes.

Science and expert ability have so much to offer in serious diseases that their treatment can no longer be conducted by a single individual. Teamwork is necessary. There are urinalyses, blood examinations, *x*-ray examinations, bacteriological studies, ureteral catheterizations, and many other tests and methods which require expert knowledge. This is best secured in the hospital. Under present conditions the rich can afford to have it brought to them; the poor secure it not at all, or only in some of the better municipal hospitals; the great middle class can not afford this team-work either at their homes or in the hospital, and accordingly they suffer for want of the best that science can offer. This is the oidium of the passing régime, which the new order of things should correct.

In every community should be found a perfectly equipped *x*-ray laboratory, as complete as science can make it. Surgical treatment should take its place along with the other specialities. A corps of surgeons, with a central equipment, for a given population should be provided. The surgical arrangement should be modified to the needs of the community. In industrial centers, dressing stations would be essential. Many of the human disasters of the passing form of industry are suffered largely because the intensive machine work of the present day is ruthless in its disregard of human life.

No discussion of the destiny of surgical treatment is adequate unless it calls attention to these chaotic industrial conditions, for the most important consideration as an adjunct to treatment is the consideration of prevention.

If it is the duty of surgery to bind up the wounds, it is also its duty to raise its voice against the conditions which cause the wounds. Science and art are not worth keeping alive if they presume aloofness from the great fundamentals of human justice.

The reorganization of society in which the surgeon must participate is now in progress. It must be borne in mind that all social activities are involved. The change runs into all of the bypaths of economic life. It is a part of a great human movement. Things are to be done because they need to be done, and not for the sake of making money with the human value of the work as a by-product. The function of the surgeon will be to relieve suffering and cure disease. It will not be to make money by relieving suffering and curing disease.

Under these more normal conditions scientific competition will be stimulated. There will be competition among health officers to keep down morbidity in their respective districts, and to show the best results in treatment. There will be wholesome competition among physicians and surgeons to attain to excellence in their work. The best results are being secured today where scientific men are carrying on their work unhampered by economic competition in the struggle for existence.

Individual initiative is destined to be stimulated under these conditions. It is a noteworthy fact that the great discoveries in science. the discoveries that have contributed the most to human life, have not been inspired by the reward of money.

Keeping people well and restoring them to efficiency is the supreme function of the medical profession. Society is going to demand that our art be employed to that end alone. That is to be our free and untrammeled work. And it will be for this that the world will bestow its rewards.

APPENDIX

SURGICAL MATERIALS

Formaldehyd-phenol in Camphor-paraffin.—This combination was worked out by K. Connell (Surg., Gyn. and Obst., July, 1918) as an antiseptic for application to infected wounds. It combines the rapid sterilizing property of formaldehyd with the slow antiseptic action of phenol. The irritating property of the former and the toxic property of the latter are mitigated by combining them in the camphor-paraffin from which they are slowly liberated. This combination is especially useful in lacerated infected wounds as a primary dressing before infective inflammation has begun. It is prepared as follows:

A. To 70 parts by weight of pulverized camphor add 30 parts of phenol, liquefied by heat. The result is a clear solution.

B. Melt together 3 parts of paraffin of 52°C. (125°F.) melting point and 9 parts of paraffin oil, adjusting the proportions until the mixture frosts on the bulb of a test thermometer at 40°C. (104°F.).

Add 45 parts of the camphor-phenol mixture (A) to 50 parts of the paraffin mixture (B). This produces a solution (AB) freezing at 35°C. (95°F.).

C. Then prepare 10 per cent. of formaldehyd in alcohol. This is most readily accomplished by adding formalin to alcohol and dehydrating by means of desiccated sodium sulphate.

To 9 parts of the camphor-phenol-paraffin mixture (AB) at 40°C. slowly add 5 parts of the formaldehyd-alcohol (C). This results in a clear solution which freezes and melts at 36°C. (97°F.).

This solution may be kept stored in bottles with paraffined corks, or it may be poured directly onto tightly wadded gauze packing ready for use.

In using this preparation in wounds, free surgical drainage should be secured. Gauze saturated with the antiseptic should be packed into the clefts and pockets of the wound. The wound should be packed firmly excepting at the drain exits, which should be packed loosely. It should be spread as a sheet on open wounds and covered with paraffined gauze. If the wound is to be treated by primary suture, all dead matter should be removed, the antiseptic painted or sprayed on the wound surfaces, and the wound sewed.

This combination is not so useful in suppurating wounds as are the chlorin antiseptics. To be on the safe side not more than 60 Gm. (2 ounces) of the mixture should be introduced in a wound.

The formula of the mixture by weight is as follows:

Formaldehyd	0.5 per cent.
Phenol	13.5 per cent.
Camphor	31.5 per cent.
Alcohol	4.5 per cent.
Paraffin (52°C.) and paraffin oil	50.0 per cent.

Formalin-glycerin solution, advocated by J. B. Murphy in the treatment of joint infections, requires at least twenty-four hours before it is

ready for use. If employed before that length of time has been given for complete solution, pure formalin may be brought in contact with the tissues and cause serious damage. It takes about sixteen hours as a minimum period for formalin to dissolve in glycerin. Twenty-four hours guarantees solution.

The 2 per cent. solution when injected into a joint produces an enormous degree of polynuclear leukocytosis. Murphy called attention to the fact that tuberculosis is healed by the formation of connective tissue and encapsulation of the disease, and not by polynuclear leukocytes; whereas acute infections are combatted by the polynuclears.

These cells have not only the power of phagocytosis, but when they perish they liberate trypsin. This ferment converts albuminoids into peptones. This digestion of dead material rapidly clears up the seat of infection.

In *gonorrheal arthritis*, it was Murphy's practice to proceed as follows: As soon as the disease in the joint manifested itself by a chill, extension is applied in the knee-joint, 25 pounds. Then an autogenous vaccine is made from the urethral discharge and injected in large enough dosage and often enough to give a decided reaction. Then the joint is aspirated, and through the same needle 15 c.c. of 2 per cent. formalin in glycerin are injected. If the temperature continue materially above normal the joint should be aspirated again in twenty-four hours, and if necessary, again in forty-eight hours. More than one injection need not be made unless the temperature remain high. Rarely are more than two injections of the formaldehydglycerin solution needed. The joint should be well inside of four weeks.

Mercuric chlorid poisoning has been studied by H. B. Weiss (Jour. Am. Med. Assoc., Sept. 28, 1918) and the treatment placed upon a more scientific basis than ever before. The treatment consists of an early washing out of the stomach and intestine and the introduction of sufficient alkali to overcome the acid intoxication. This should be done as early as possible. The stomach is best washed out with a mixture of 1 liter (1 quart) of milk and the whites of three eggs, followed by a saturated solution of sodium bicarbonate until the fluid returns clear. Before the stomach tube is removed 90 Gm. (3 ounces) of crystalline magnesium sulphate are dissolved in 180 c.c. (6 ounces) of water and allowed to remain in the stomach. An enema of soap suds is given.

The alkali is introduced by mouth, by rectum and intravenously as soon as the stomach washing is finished. *Fischer's solution* is given intravenously. This consists of crystallized sodium carbonate, 10 Gm. (or ordinary dry sodium carbonate, 4.2 Gm.); sodium chlorid, 15 Gm.; and distilled water, 1000 c.c. From 1000 to 2000 c.c. of this solution are given as a first dose. The alkaline medication is continued by giving 240 c.c. (8 ounces) of "imperial drink" every two hours. This consists of potassium bitartrate (cream of tartar), 4 Gm. (1 dram); sodium citrate, 2 Gm. (½ dram); sugar, 2 Gm. (½ dram); water 240 c.c. (8 ounces); and flavoring of lemon or orange juice.

Diet is not restricted. The urine should become alkaline to a saturated solution of methylin red in alcohol. Nephritis is the danger, and the urine must be kept alkaline to methylin red to save the patient's life. If it does not respond to this reaction and if the excretion of urine is not freely maintained after the first intravenous injection, a second intravenous injection should be given on the following day, and the administration of alkali by the mouth or rectum continued.

Chloramin Wax.—A useful ointment for superficial wounds, is made as follows:

Balsam of Peru	3	Gm. (48 grains)
Tincture of benzoin	3	Gm. (48 grains)
Chloramin-T	4.5	Gm. (70 grains)
Virgin wax	100	Gm. (3½ ounces)
Sterilized olive oil	200	Gm. (6⅔ ounces)

Delbet's paste, for wound dressings, is as follows:

Tincture of iodin	6	c.c. (93 minims)
Chloroform	6	c.c. (93 minims)
Wax	50	Gm. (800 grains)

Alexander's paste, a valuable application in the treatment of burns, is of the following composition:

Ichthyol	4	Gm. (60 grains)
Olive oil	12	Gm. (3 drams)
Wool fat (adeps lanæ)	105	Gm. (3½ ounces)

INSTRUMENTS

To Make Curved Needles.—In the absence of curved needles, the ordinary straight sewing needle may be converted into a curved needle by heating it in a flame. An alcohol flame, a gas burner or an ordinary oil lamp may be used. The needle should be grasped at either end with forceps, and slowly bent to the desired curve while it is in the flame.

ANESTHETICS

Administration of Liquid Anesthetics by Mouth.—J. T. Gwathmey has found that anesthetics may be given by the stomach and analgesic effect obtained without harm to the gastrointestinal tract. Ether lends itself best to this method. It is given in a 50 per cent. mixture with liquid petrolatum. The following formula is used: ether, 15 c.c. (4 drams); liquid petrolatum, 15 c.c.; and peppermint water, 5 drops. The disagreeable taste of the ether is disguised by taking a mouthful of port wine immediately before and after the analgesic dose. Usually no nausea or other discomfort follows. No preliminary preparation of the stomach is necessary although it is best not to give the analgesic directly after a meal. Because of the slow, gradual, and constant liberation of the ether from the oil a mild analgesia results.

A dose of 15 c.c. (4 drams) of ether given in this way causes the patient to become drowsy or to fall into a light sleep in twelve or fifteen minutes. A state of analgesia exists for twenty or thirty minutes, during which painful dressings and slight operations may be done. The patient is conscious and may converse during the operation. If a procedure is very painful a small amount of inhalation anesthetic may be given. Local anesthesia may advantageously be combined with this method. The amount of ether or chloroform required by inhalation in these cases is small. A healthy patient may be given a second dose by mouth of 15 c.c. of ether with the same amount of petrolatum in about half an hour after the first dose if it seems indicated.

Gwathmey and Karsner (Jour. Am. Med. Assoc., April 6, 1918) found that chloroform also may be given by mouth in this manner. The combination used is, chloroform, 2 to 4 c.c. (½ to 1 dram); ether, 14 c.c. (3¾ drams); and liquid petrolatum, 14 c.c.

Pure Ether.—J. H. Cotton (Canadian Med. Assoc. Jour., Sept., 1917) discovered a new process for producing ether. He believes that pure ether

is not an anesthetic but produces upon inhalation only a transitory stimulation such as alcohol would produce. The anesthesia which results from commercial ether is due to certain impurities Of the two impurities in commercial ether, one produces anesthesia and the other produces the dangerous symptoms. Cotton has succeeded in making pure ether and charging it with the anesthetic substance. W. G. Hudson (Med. Record, March 16, 1918) describes the effect of "Cotton-process ether" as peculiar. The undesirable after-effects seem to be eliminated. A new type of anesthesia is produced in which the patient is maintained in a state of abolition of sensation but perfect consciousness is preserved. The patient can even walk about while in this analgesic state. When the amount administered is reduced, sensation returns; when the dosage is increased the patient passes into ordinary surgical anesthesia with loss of consciousness. There is no stage of excitement.

PREPARATION FOR OPERATION

Purgatives in the Preparation for Operation.—The value of cathartics is a tradition. When in doubt, purge, seems to have been a medical axiom. It was natural that surgeons should have used the cathartic as a preliminary to operation. Its use began when the performance of an operation was a momentous event for the surgeon, the patient and the community, and the purge was looked upon as the rite most fitting as a preparation for the great event. It had its value, and it has had its abuses.

In Vol. II, page 565, under preparation of patients for operation, attention is called to the fact that infection from dry or soft solid fecal contents of the bowel is not to be feared, but fluid feces are apt to contain virulent bacteria. W. C. Alvarez (Surg., Gyn. and Obs., June, 1918) has recently experimented upon animals and arrived at the conclusion that purgatives should not be given before operations. He found that some of the purgatives are irritant poisons. Others cause unbalancing of intestinal absorption and interfere with the natural processes of osmosis. They produce pathological conditions, and weaken rather than strengthen the vital resistance.

The dehydration of the tissues caused by catharsis and the disturbance of the salt balance are particularly objectionable before an operation in which there may be bleeding and vomiting. Alvarez found that there results from fluid feces an increased growth of bacteria; there is evidence that there is an increase in the absorption of toxins, and a greater permeability of the intestine to bacteria. Normal peristalsis is interfered with by weakening some parts of the intestine and irritating others. Flatulence is produced by liquefying the feces in the large intestine.

Surgery is under obligations to Alvarez for calling it to account for the crimes of purgation. To disturb a patient's sleep, disorganize the abdominal equipoise and produce a serious weakening of his resistance by the administration of purgatives at the critical eve of an operation has not been to its credit nor to the patient's advantage. Alvarez advises that if the patient's bowels move normally every day, and particularly if they move normally on the morning of operation, as they probably will do if the breakfast is allowed, no enema even need be given. Enemas are indicated only for those who are definitely constipated or who are to undergo operation on the lower colon or on the pelvic organs.

Solid food should be given as soon after operation as possible on account of its tonic effect on the gastrointestinal tract and its power to restore downward peristalsis. Water by stomach has the same advantages and

is much to be preferred over proctoclysis. The rectal drip tends to cause reverse peristalsis, nausea, and gas-pains.

All that has been said of pre-operative purgation applies to after-treatment. If a movement is needed it can best be secured by means of enema. Laxatives and cathartics are capable of causing serious disturbances of healing.

All of this new point of view has been growing among surgeons for many years. Now that it has culminated in positive action we should beware lest the pendulum swing too far. There will always be a use for laxative remedies. The middle course, directed by the wise discrimination of the experienced surgeon, must ultimately be followed.

CLOSURE OF WOUNDS

Infolding Purse-string Suture.—The first description of an infolding purse-string suture (Vol. I, page 201) applied to the gall-bladder was by W. H. Williams. H. A. Shaw was the first to describe this suture in connection with the broad ligament; he applied to the broad ligament the same suture as Williams had applied to the gall-bladder. This is the simple mattress suture adapted to the purse-string principle. The suture which Shaw applied to the gall-bladder is a distinct contribution to this subject and is essentially different from that of Williams. Shaw's purse-string suture pulls up more easily; it is illustrated on page 202, Vol. I.

To Prevent the Slipping of Knots.—Knots tied with heavy catgut or kangaroo tendon, if there is much tension on the suture, are prone to slip. In using kangaroo tendon in bone-grafting, it is imperative that the suture hold firmly. To guarantee this security F. H. Albee ties a knot of fine catgut within the knot of heavy material. The first half of a knot in a kangaroo suture is tied; then a piece of fine catgut is placed across the knot transversely to the course of the heavy suture; the second half of the knot is tied across the fine catgut; the fine catgut is then tied securely across the knot of the heavy suture. This tightly secures the knot. Four ends of thread then require to be cut off—two heavy and two fine.

FOREIGN BODIES

To Remove Fish-hooks, Crochet Hooks, and Other Barbed Bodies from the Tissues.—An instrument such as a fish-hook, the barb of which has penetrated the tissues, can not be made to retrace its path of entrance without a very considerable cutting operation. If there are no important structures in the way, it is best removed by causing its point to continue on its course and to emerge through the skin, causing a second wound. The barbed end may then be cut off with metal-cutting forceps, snapped off with pinchers, or filed through and broken. With the barb removed the hook may then be drawn out by causing it to retrace its path of penetration. I first saw this method practised upon myself by a country doctor when I was a small boy; I have used it many times since that with much satisfaction.

INFECTED WOUNDS

Flavine in the treatment of infected wounds has stood the test in a large series of cases. Its application is so simple that it commends itself in contrast with the methods which require elaborate and complicated technic. The infected wound is cleansed of foreign matter, dead tissues are cut away, and the wound is filled with gauze richly soaked with 1 : 1000 solution of

flavine. There is perhaps an advantage in combining it with hypertonic saline solution. One to 500 and 1 : 2000 solutions are also used.

Every pocket and crevice should be reached by the flavine solution. Before introducing the gauze the fluid may be injected with a syringe. The wound after it is packed should be protected with an impervious covering. If a yellowish pellicle forms over the wound it is best to change the antiseptic, and for a few days use hypochlorite solution, eusol, or some other effective antiseptic. The early use of flavine seems highly advantageous. Wounds are brought to a state for suturing with a promptness scarcely second to that of the hypochlorite method. *Acriflavine* acts more rapidly than *proflavine*. Flavine causes the formation of a fibrinous membrane on the wound surface. This is completed by the third or fifth day when acriflavine is used, and by the fifth or seventh day when proflavine is used. An infected wound which has been packed with 1 : 1000 or 1 : 2000 flavine solution and gauze, on the second to the fourth day, has a dry, dull, sticky appearance. It is characterized by the absence of discharge and granulations. A yellowish discoloration may be present.

Flavine does not render infected wounds bacterially sterile; it is antiseptic, but not disinfectant. It does not produce necrosis of tissue when used in strength not greater than 1 : 1000; but it prevents the spread of infection. After its use, the ultimate sterilization of the wound is easily accomplished by eusol if desired.

Brilliant green acts similarly to flavine. It is used in the strengths of 1 : 1000 and 1 : 500 in normal salt solution and 1 : 500 in 0.5 per cent. chloretone. The latter is most satisfactory in treating recent infected wounds. An advantage of this antiseptic is that dead and seriously damaged tissue is more deeply stained by the green than is healthy tissue. For this reason it is useful in determining what tissues to excise. The tissues which hold the stain, excepting the skin, should be removed.

Magnesium sulphate in the treatment of infected wounds continues to give good results. Every soluble mineral substance and most soluble vegetable substances when introduced into infected wounds seem to be followed by healing. A. E. Morison (British Med. Jour., March 23, 1918) reported the results with magnesium sulphate made into a creamy paste. The cream is prepared as follows: 712 Gm. (1½ pounds) of magnesii sulphas exsiccatus are mixed with 328 c.c. (11 ounces) of phenol-glycerin (1 : 10). The dried magnesium sulphate is a fine white powder. The phenol-glycerin is put in a warm mortar and the magnesium salt added while it is stirred with a warm pestle. The creamy mixture is so hygroscopic that it must be kept in a stoppered jar to protect it from the air. A culture is taken of the wound secretions, the wound is packed and thickly covered with the salty paste, and protected with a dressing. The dressing is left on for from three to ten days. A profuse discharge of serum takes place from the wound, and more dressing may have to be applied.

When the wound is dressed the surface should be characterized by bright granulations. A similar dressing spread thickly on gauze is again applied. Deep wounds must be filled with the cream by means of a syringe. After a few dressings, magnesium sulphate solution is substituted for the paste. The wound may then be sutured or skin grafted.

In the case of deep wounds with compound fractures the cream is applied every three or four days. Then the wound is opened up under general anesthesia, dead bone removed, the wound washed out with ether or gasolene, dried, and filled with bipp or X. Y. Z. (xeroform) paste, the deep layers of the wound united with catgut sutures, and the skin united with retention

sutures of strong silk. The skin is protracted with gauze smeared with bipp paste.

Primary Suture of Infected Wounds.—If the surrounding tissues are not the seat of infective cellulitis, and if the circulation about the wound is good, infected wounds may be closed by suture after the proper preliminary treatment, and healing may thus be hastened. Devitalized tissue and badly infected removable tissue should be cut out with curved scissors. All bleeding should be checked, and the wound should present fresh clean-looking surfaces. A tight gauze packing for a few minutes should complete the drying. As the gauze is rapidly removed the wound is thoroughly swabbed with 5 per cent. solution of iodin in alcohol. Excess of iodin should be taken up with dry gauze. The wound should look dry and as though recently varnished. A small drain of gauze or wicking is introduced to permit the escape of serum, and the wound is sewed with silkworm-gut or paraffined thread.

This application of iodin is not absolutely necessary in all cases. It need not be used in small wounds and in wounds in which the devitalized tissues are removed in a mass. When it is used it causes an increase of serous oozing, and because of the layer of devitalized cells union is not secure enough to remove the sutures until the twelfth day.

Delayed primary suture of infected wounds offers advantages in many cases. Excision of the damaged tissues of the wound is performed, and the wounds packed with bipp, flavine, ether, magnesium, plain gauze, or other material or medication. The next dressing is done under general anesthesia. The outer dressings are first removed and the skin washed with 2 per cent. picric acid in alcohol. The packing is then removed from the wound with forceps under absolute aseptic precautions. This should be done carefully. Bleeding should not be provoked. A wound which has been packed with bipp has an oily, dry appearance, without granulations, and with islands of paste showing here and there. If blood-clot is found in the wound it should be washed out with aseptic solution. If bleeding is present it should be checked. No further treatment is necessary; the wound is sutured with silkworm-gut or paraffined silk. In deep wounds the parts should be brought together with buried sutures of catgut. If the wound is moist cigaret drains should be employed. The drains may be removed on the second day. In large wounds, such as amputation stumps, rubber tubes should be used.

It is possible to suture wounds even in the presence of suppuration. With adequate drainage provided the result commonly attained is a smaller wound with less discharge.

Combined Instillation and Paste Treatment of Infected Wounds.—This method is especially useful in infected compound fractures. The wound is first freely opened, devitalized tissues excised, and the wound cleansed. Tubes are inserted and the intermittent instillation of hypochlorite solution practised. As soon as suppuration is somewhat controlled, the instillation treatment is discontinued. The surface of the wound and the surrounding skin are cleansed with alcohol, the surfaces of the wound are then dried, and the bipp paste of Morison freely smeared over all surfaces and packed into all crevices and bone cavities. Gauze impregnated with bipp paste and holding between its folds a mass of the paste is placed everywhere in contact with the wound surfaces. The wound should be covered with paste and gauze and the part well immobilized. A wound thus treated will usually discharge so little that it will require to be dressed not before the fourth to the fourteenth day. Even though discharge comes through the dressing it is not prone to become foul, nor do granulations tend to grow into the gauze. This treatment substitutes the simple treatment of the closed

wound for the frequent dressings of the instillation method and soon makes possible secondary suture of the wound.

The Embalming Treatment of Infected Wounds (Method of Mencière).—This method aims to fill the wound with a soothing antiseptic which shall inhibit infection and permit later attention to the wound at a more propitious time. The formula most lately employed is 10 Gm. (2½ drams) each of guaiacol, eucalyptol and balsam-of-Peru; 10 Gm. of iodoform; 100 Gm. (3 ounces) of alcohol; and ether enough to make 1 liter (Progrès Mèdical, April 6, 1918). In bad gangrenous wounds, requiring one or two applications only, 10 Gm. of benzoic acid are added to the formula. The fluid is sprayed into the wound. It prevents bacterial growth for about twenty-four hours.

OPEN WOUNDS

Adhesive Plaster as a Wound Dressing.—In Vol. I, adhesive plaster is described as a dressing for ulcers. C. Mancini (Policlinico, Rome, Aug. 8, 1918) recommends it as a dressing for wounds. Narrow strips of adhesive plaster are applied tightly, extending well onto the skin on either side. A space should be left between each strip for the escape of secretions. A gauze dressing is applied over the plaster. The strips may be left on for six or eight days. The gauze may be changed as often as necessary. The strips may be sterilized by passing them rapidly through a flame, or by soaking in alcohol and then burning out the alcohol.

To hasten the growth of epithelium, D. Taddei (Riforma Medica, March 30, 1918) promoted the healing of skin by the use of iodin. Iodin has long been used for this purpose. A strip of adhesive plaster is laid on gauze and its adhesive surface swabbed with tincture of iodin (10 per cent.). This is allowed to dry, and it is then cut into strips 4 or 5 mm. (⅕ inch) wide and 3 to 8 cm. (1 to 3 inches) long. These strips are applied to the edge of the granulating wound. A strip should lie 1 mm. on the epithelial margin of the wound and the other 3 or 4 mm. should lie on the granulation tissue. Three to six of these strips are applied around the margins of the wound. The iodin seems to stimulate epithelial growth and protect the granulations and tender cells when dressings are changed. The strips are renewed as the epithelium advances. The plaster without the iodin seems not to promote the rapid growth of epithelium as the iodin does.

WOUND COMPLICATIONS

Delirium Tremens.—Prolonged hot baths and hot packs given twice daily have a decided value in this disease. Alkaline treatment should also be given to counteract the acidosis. This is best administered by the "imperial drink" which consists of potassium bitartrate (cream of tartar), 4 Gm. (1 dram); sodium citrate, 2 Gm. (½ dram); sugar, 2 Gm.; water, 240 c.c. (8 ounces); and flavoring of lemon or orange juice. This amount may be given every two hours. In more desperate cases the alkali may be given by rectum or by venous infusion. Fischer's solution is used. This consists of crystallized sodium carbonate, 10 Gm. (or ordinary dry sodium carbonate, 4.2 Gm.); sodium chlorid, 15 Gm. (½ ounce); and distilled water, 1000 c.c. (1 quart). From 1000 to 2000 c.c. of this solution are given in a vein as an initial dose. This should be promptly administered, and repeated, if the patient is cyanotic or pale, with rapid pulse and clammy, perspiring skin. If the urgency is not so great, this solution may be given by proctoclysis.

In connection with the above treatment, a preliminary catharsis is essential. Spinal puncture and withdrawal of from 25 to 75 c.c. of cerebrospinal fluid is called for if the patient has delirium and hallucinations. As much as 100 c.c. (3½ ounces) may be withdrawn (see Vol. I, page 526). The spinal puncture may be repeated if the delirium continues.

Tetanus.—There is strong evidence that the prophylactic effect of injections of antitetanic serum lasts not much longer than ten days. The British War Office Committee on the Study of Tetanus recommended that in patients presumably infected with tetanus four injections should be given even though the wound has healed primarily. A primary injection is given at the time of the wound. The first should be given as soon as possible. The second injection should follow the first in about seven days. The third and fourth should follow at the same intervals. It is found that the dangers of anaphylaxis are negligible when prophylactic doses of 500 units, contained in 3 c.c. of horse serum are given subcutaneously whatever the interval may be.

The report of the committee recommends that the primary injection should be 500 units, and the second, third and fourth the same amount. It is recommended that in operating on wounds or at the site of wounds, even though they are healed, a prophylactic injection of serum invariably should be given if the operation be performed at a greater interval than seven days from the last injection. "This precaution is very necessary as numerous cases have occurred in which the performance of a simple operation has been followed by an attack of tetanus, although in many cases the primary wound had been healed several weeks before operation."

The specific treatment of tetanus recommended by the British Committee lays emphasis on the value of the spinal route of injection. The serum is introduced by lumbar puncture into the subarachnoid space. Large doses of serum are injected. The injections are repeated on two, three or four days in succession. This may be combined with intramuscular injections. The more acute the case the larger should be the dose. The aim is to saturate the system with antitoxin as rapidly as possible. From 50,000 to 100,000 units may be given during the first five days of treatment.

The high potency serum should be used for spinal injections because the amount of fluid which can be introduced is limited. The amount of cerebrospinal fluid which can be withdrawn at one time will as a rule not be more than 20 c.c. It is usually best not to inject more serum than the amount of fluid withdrawn. When little or no fluid can be withdrawn it is best not to inject more than 20 c.c. (5½ drams) of serum, and that should be injected very slowly.

The spinal injections may be repeated daily for three or four days. Injections by other routes may be made during the same period. As the symptoms abate the size of the doses is diminished and the intervals lengthened.

The British Committee finds that there is no evidence that phenol has any curative effect. They do not recommend its use.

Gas Gangrene.—The indications in this disease are destruction of the bacillus and increasing the patient's resistance against it. A 1 per cent. solution of chlorhydrate of quinin, hypochlorite solution, and other antiseptics have been more recently recommended. Excision of gangrenous tissue is called for. If amputation is done it should be by the flapless method. The antitoxin worked out by C. G. Bull and I. W. Pritchett (Jour. Exper. Med., July, Oct. and Dec., 1917) offers decided hope in the treatment of this disease.

SYPHILIS

Mercurial-salvarsan Treatment of Syphilis.—Syphilis has usually been treated by salvarsan followed by mercury. L. Bovy (Bull. de la Soc. Med. d. Hopit., Oct. 26, 1917) reversed this process and began the treatment with massive doses of mercury and continued treatment with small doses of salvarsan. Mercuric benzoate is used in 3 or 6 per cent. solution, by intravenous or intramuscular injection. The initial dose is 4 c.c. (64 minims) of the solution every day or every second day. This is increased to 5 to 10 c.c. (80 to 160 minims). In the course of ten or fifteen days 8 to 10 c.c. (130 to 160 minims) are easily tolerated. The mercury is thus continued for twenty-five or thirty days. A total dosage of 1.10 to 2.20 Gm. (17 to 34 grains) of the mercurial salt is given in eighteen or twenty injections. The signs of contagion have usually disappeared by the tenth day. If the blood reaction shows that treatment should be continued, then one or two injections of salvarsan complete the cure.

Benzoate of mercury contains 45 per cent. mercury. It is but slightly soluble in water, but it is freely soluble in a solution of sodium chlorid.

BLOOD TRANSFUSION

Tests of Blood of Donors for Transfusion.—The technic of agglutination tests is described in Vol. I, page 355. To this test R. I. Lee (British Med. Jour., No. 2, 1917, 684) added a simple and rapid method for determining the fitness of donors for transfusion based on the mendelian law. An arbitrary classification into four groups is used. The donor and recipient need not be in the same group, but it is important that the serum of the patient does not agglutinate or hemolyze the red corpuscles of the donor. In the ordinary transfusion only about one-twelfth to one-fifth of the total blood volume of the patient is added from the donor. This high dilution of the donor's serum prevents its acting in a detrimental manner. The patient's own serum also protects his blood cells. Therefore, even though tests show that the donor's serum may agglutinate or hemolize the patient's red corpuscles, transfusion may still be permissible and harmless.

Lee's table which shows the interrelationship of the different groups is as follows:

	Serum of group			
	1	2	3	4
Cells of Group 1	−	+	+	+
Cells of Group 2	o	−	+	+
Cells of Group 3	o	+	−	+
Cells of Group 4	o	o	o	−

\+ = Agglutination and hemolysis.
o = No agglutination and hemolysis.

Group 1 may receive blood from any donor; the serum of this group will neither hemolyze nor agglutinate the red cells of any group. The cells of Group 1, on the other hand, are agglutinated and hemolyzed by all other serums except that of its own group. This group is small. A patient in Group 1 is known as a universal recipient. Group 4, in contrast to Group 1, has its cells agglutinated and hemolyzed by no group, but its serum will agglutinate and hemolyze the red cells of all other groups. Group 4 is the largest group. It is known as the universal donor group, since the blood from

this group can be transfused with safety into any patient. If the patient belongs to Group 4 he can receive only the blood of Group 4.

Persons within the same group vary greatly in the potency of the agglutination and hemolytic action of their serums. A cross-transfusion may in one instance result in an immediate fatality from destruction of red blood cells; hemoglobinuria and jaundice but not death in another; and in only mild symptoms in a third patient. The minimum procedure consists in establishing the fact that the patient's serum does not agglutinate the donor's cells. A rapid test may be made on a slide, to determine the action of the patient's serum upon the red corpuscles of the donor.

Lee's method provides that supplies of serums of known groups are kept on hand ready for use. The known persons or test persons serve to act as a supply to the known serums. The routine method of procedure is as follows:

A number of possible donors are tested with the serums of Groups 2, 3 and 4, and their names and addresses recorded. If there is sufficient time the blood of the patient also is tested and classified in one group or another; this is in order to use donors from groups other than from Group 4 as far as possible. In emergencies no further tests are necessary. Transfusion is immediately performed with a donor from Group 4.

Transfusion with Preserved Red Blood-cells.—The introduction of the citrate method of transfusion made it possible to transport blood from a distant donor to the recipient, and successful transfusions were made with blood which had been drawn for several hours. The advantages of preserving blood are obvious, for the longer blood can be kept in a usable form the less of an emergency procedure does the securing of a donor become. The experimental basis for extending the period of blood preservation was worked out by P. Rous and J. R. Turner (Jour. Exper. Med., 1916, xxiii, 219). They demonstrated that blood mixed with a solution of dextrose and sodium citrate and kept cool could be used after several weeks. The red cells not only remained whole but they retained their viability. The solution used consisted of 5.4 per cent. dextrose and 3.8 per cent. sodium citrate. Both of these solutions are isotonic with blood plasma. The optimum proportions employed were, 3 parts of blood, 2 parts of citrate solution, and 5 parts of dextrose solution. The mixture is placed in the ice chest. The red cells settle, but no signs of hemolysis appear even after the cells are repeatedly stirred up. Washing the cells in Locke's solution caused no evidence of loss of integrity. Human blood kept in this way showed no apparent deterioration at the end of four weeks. A normal rabbit was bled up to half of its blood volume, and when infused with rabbit's blood which had been preserved by this method for two weeks was promptly restored to a healthy state, the red cell count being normal. The condition was only temporary for by the end of the second day the transfused cells had practically all disappeared. Although the rabbits were left anemic they seemed otherwise normal.

O. H. Robertson (Brit. Med. Jour., June 22, 1918) made successful experiments with this method with human blood. He made up solutions on a basis of 500 c.c. (1 pint) of blood. This required in round numbers 350 c.c. (12 ounces) of isotonic sodium citrate solution and 850 c.c. (29 ounces) of isotonic dextrose solution. These two solutions must be made up and autoclaved separately. Freshly distilled water should be used. If powdered dextrose can not be obtained, liquid glucose may be used instead; 2 Gm. (30 grains) of liquid glucose are equivalent to 1.6 Gm. (25 grains) of powdered dextrose.

To make up 850 c.c. (29 ounces) of a 5.4 per cent. solution, 46 Gm. (735

grains) of powdered dextrose or 57.5 Gm. (920 grains) of liquid glucose are used. The glucose is best handled in a 20 per cent. stock solution. Enough of this stock solution for making six lots of "isodextrose" is made by dissolving 360 Gm. (12⅘ ounces) of liquid glucose in sufficient distilled water to bring up the total volume of the solution to 1800 c.c. (61 ounces). This should be filtered through coarse filter paper. The solution should be sterilized if it is to be kept. The "isodextrose" is made by diluting 287 c.c. (9⅔ ounces) of this concentrated solution with distilled water up to 850 c.c. (29 ounces) in a clean 2-liter (2-quart) bottle. The bottle should be stoppered with a cotton plug covered with gauze. Bottles with parallel sides are used. This solution should be sterilized in the autoclave for one-half hour at a temperature of 105°C. (221°F.); this is equal to 3 pounds of steam pressure. A temperature of 105°C. should not be exceeded as the glucose may decompose at a higher temperature.

The 3.8 per cent. sodium citrate solution is also most conveniently made from a 20 per cent. stock solution. An amount of this stock solution sufficient to make six lots of "isocitrate" is prepared by dissolving 90 Gm. (3 ounces) of sodium citrate in distilled water up to a volume of 450 c.c. (15 ounces). This should be filtered. If it is to be kept it should be sterilized. The "isocitrate" is made by diluting 66.5 c.c. (17½ drams) of the 20 per cent. solution with distilled water up to 350 c.c. (12 ounces). These 350 c.c. amounts are best sterilized in small bottles of the size for transfusing the blood. The mouth of the bottle should be stoppered with cotton and gauze, and the whole sterilized at 105° to 110°C. (221° to 230°F.) in the autoclave for one-half hour.

For procuring the blood, persons belonging to Group 4 of R. I. Lee's classification are used. The blood is received in the sterilized bottle containing the "isodextrose." Before the solutions are mixed a mark, A, is made on the bottle at the upper level of the dextrose solution. Then 350 c.c. (12 ounces) of the "isocitrate" is poured in and another mark, B, made at the new fluid level. The distance AB measures 350 c.c. (12 ounces) which is about two-thirds of 500 c.c. (1 pint). A third mark is made at C, a distance above B equalling one and a half times the distance AB. This is approximately the measure of 500 c.c. (1 pint). Robertson receives the blood into the bottle through a short tube consisting of the needle, rubber tubing and glass tubing. The latter passes down as far as the solution so that the blood does not fall through the air. A second tube connected with the bottle through the rubber stopper is attached to a suction bulb which exhausts some of the air.

Into this apparatus 500 c.c. (1 pint) of blood are received, mixing with the citrate-dextrose solution. The bottle is gently rotated to mix the blood with the solution; the rubber stopper is removed; the cotton stopper replaced; the bottle labelled with the date, quantity, and name of donor; and placed in the ice chest.

The red cells settle rather slowly. Not until the end of four or five days has it settled down to about 800 or 900 c.c. (27 or 30 ounces). It can then be used, as this amount of cell suspension does not contain any more sodium citrate than is given in an ordinary citrate transfusion. If there is a probability that blood will be needed soon, 300 c.c. (10 ounces) amounts may be collected instead of the usual 500 c.c. (1 pint) and the sediment of two or more bottles combined for a transfusion. A pink tinting of the supernatant fluid probably indicates hemolysis due to infection and the blood should be discarded. By the end of the fourth week a pink coloration appears which indicates hemolysis. The blood then should not be used.

For transfusing, the supernatant fluid is drawn off by siphon. If the blood has been stored for some time the settlement of the cells may be so great that it has sunk below the total amount of blood drawn. In such a case it should be brought up to the original amount of blood by adding a diluent. A 2.5 per cent. solution of gelatin may be used for this purpose. Usually it is desirable to bring the total amount of fluid to be transfused up to 1000 c.c. Blood cells should not be poured when in solution more concentrated than normal blood.

When the proper dilution has been secured the solution is poured through two layers of sterile gauze into the transfusion bottle. The blood should not be poured so that it falls but should be allowed to flow quietly down the side of the sloping bottle. The bottle is stoppered and placed in a water bath at a temperature of 41° to 42°C. (106° to 107°F.). The apparatus for most convenient transfusion is a bottle with parallel sides, holding 1 liter (2 pints). Through a rubber stopper two glass tubes are admitted. One passes to the very bottom of the bottle and is connected by rubber tubing to the needle; the other just passes through the stopper and is connected by a bulb for pumping a little air into the bottle above the blood to force it out through the other tube. The rubber stopper should be held by a clamp or adhesive strips to prevent it being forced out by the air pressure. Ten minutes should be the minimum time for the introduction of 500 c.c. of blood. Care should be taken to close the stopcock before air bubbles pass up the tube.

In Robertson's cases the blood used had been kept for varying periods up to twenty-six days. Most of the transfusions were given with blood from ten to fourteen days old. Most of the cases were of hemorrhage. The amounts given each case varied from 500 to 1000 c.c. (1 to 2 pints). In all cases the total bulk of the fluid was brought up to 1000 c.c. by the addition of gelatin solution. The patients showed the same striking improvement as when fresh blood is transfused. The length of time the blood had been preserved seemed to make no difference in the results. The amount of hemoglobin and the post-operative variations seemed the same as when fresh blood is given. Abel, of Johns Hopkins, has shown that a dog may have all of its blood-plasma replaced by Locke's solution, and so long as the corpuscles are restored it apparently suffers no harm. This transfusion of corpuscles without the natural plasma seems quite as effective as whole blood. Such preserved blood may be transported long distances without damage.

The value of this method is very great. It obviates the disadvantages of hurrying to find a suitable donor in time of emergency. The operation is simplified because one person is involved instead of two. Every hospital should have available such preserved blood. This fluid is too precious to permit to waste. The problem should be solved by maintaining a central blood-supply station which should supply not one hospital but many. If each hospital attempts to keep its own supply to meet the maximum of emergencies there will be occasions when the four weeks' period will be passed without a demand for the blood. This loss should be prevented by enlarging the field to be supplied. The larger the demand, the more equable does it become, and the better can it be standardized. In the interest of a better coördination and socialization of surgical agencies some central hospital or laboratory should be designated in each community for blood supply purposes.

Indirect transfusion by means of glass tubes was first described by A. R. Kimpton and J. H. Brown (Jour. Am. Med. Assoc., July 12, 1913, p. 117). The tube of Vincent (Vol. I, page 354) is a slight modification of Kimpton's

tube. These tubes should be sterilized in the autoclave and before using the inside should be coated with sterilized paraffin. Vincent used a mixture of stearin, 1; paraffin, 2; and vaselin, 2. Paraffin alone which melts at 48°C. (118°F.) is entirely satisfactory, and is preferred by Kimpton. The paraffin is melted in a water bath and the tube is warmed over an alcohol flame. The tube should then be nearly filled with the melted paraffin and the cork replaced. The paraffin should be caused to flow about over the whole inside surface of the tube and cork. Some should flow out of the canula. The fluid should then be poured out of the side opening, leaving a paraffin film coating the tube. The tube may then be wrapped in sterile gauze and it is ready for use.

Kimpton (Boston Med. and Surg. Jour., Mar. 14, 1918) advised the use of the ordinary arm band employed in taking blood-pressure. The diastolic pressure of the donor should have been determined. While the tube is filling, the blood-pressure should be kept slightly lower than the diastolic pressure. This gives the desired degree of venous obstruction. The vein may be exposed by a short incision, and ligatures passed around it as for infusion. Kimpton punctures the donor's vein with a cataract knife, after tying the proximal ligature. The canula is inserted in the vein, the tube held vertically and allowed to fill by venous pressure. About two minutes are required for 250 c.c. (8½ ounces). If the tube is not filling well the donor should be instructed to open and close his hand to increase the flow.

The vein of the recipient is being made ready while the tube is filling. It is exposed and compressed distally; the proximal ligature is not tied but its ends are caught with a clamp. The tube being ready, it is removed from the donor with the side-opening uppermost. This opening is closed by the pressure of the thumb. The canula is inserted into the vein of the recipient and the tube held vertically. Before inserting the canula the surgeon should see that the vein bleeds. Fine forceps may be inserted in the opening to guide the canula. Kimpton attaches the bulb of a cautery apparatus to the side opening and makes gentle air-pressure upon the blood until the tube is emptied. If the cork should jump out the palm of the hand may be used to close the tube.

The canula should be withdrawn while there is still a little blood in the tube. Several tubes may be used, or if the same tube is employed repeatedly it should be washed out each time with salt solution. Incising the veins may be obviated by using a needle, which should be connected to the canula by a short rubber tube. Several tubes may be filled without removing the needle from the donor's vein. The rubber tube and needle need not be treated with paraffin; they should be moistened with salt solution.

Fig. 206, page 354, Vol. I, shows the tube provided with a bulb reversed for creating suction in the tube. This is rarely necessary. The tube as commonly used by Kimpton is without the needle.

Abdominal Blood.—We have also to thank Kimpton for suggesting the use of blood found in the abdomen in cases of abdominal hemorrhage. In certain recent cases of rupture of the spleen and in other conditions in which clean blood is poured into the abdomen, it should be entirely possible to citrate this blood at once and return it to the patient's blood-vessels.

SKIN

Pruritus.—Reference has been made to the treatment of *pruritus ani* by means of an autogenous vaccine (page 65). D. H. Murray reported further on this method before the Section on Gastro-Enterology and Proctology

of the Am. Med. Assoc., at its 69th Session in 1918. The technic which he described is as follows: The skin about the anus is washed with non-irritating soap and water and rinsed with sterile water. No antiseptic is used. The cleansed skin is then rubbed with a sterile swab to catch the specific infecting *Streptococcus fecalis*. The swab is then rubbed on the surface of solidified beef-agar in a Petri dish. The agar medium should show a 0.5 phenolphthalein test for acidity. The *Streptococcus fecalis* develops in small clear colonies which are easily distinguished from those of *Staphylococcus albus*, *Bacillus coli* and other larger colonies.

The *Streptococcus fecalis* is then subcultured on slants in tubes of the same kind of agar as is used for the isolation cultures. A few tubes of these cultures are made and the bacteria killed either with 0.5 per cent. phenol solution or with 0.33⅓ per cent. tricresol solution. The sterility of the vaccine should be proved. A standard vaccine is made containing 2 billions of dead bacteria to the cubic centimeter. It is kept in a sealed bottle in a cool place. When used it should be shaken to distribute the organisms evenly. The beginning dose is 0.18 c.c. (3 minims), injected under the skin of the buttock. The injection is given at intervals of two days, each injection being increased from 0.18 to 0.30 c.c. (3 to 5 minims). If severe reaction takes place the dosage is not to be further increased. Four or five injections usually are made before reaction is seen. The treatment aims to continue until abatement of symptoms is secured. This may require as many as seventy doses, or as few as seven in Murray's experience. He has obtained distinct relief for 88 per cent. of his patients thus treated. The dosage after reaction begins must then be regulated by the surgeon's judgment.

J. M. Frick called attention to the necessity for care in excluding cases of eczema marginatum and other infections from this treatment. He obtained the organisms by abrading the skin surface of the pruritic area just as is done for ordinary vaccination. The serum which oozes up is taken on a platinum needle and planted in ascitic agar as a culture medium. He reported 95 per cent. of cures.

HEAD

The Intradural Approach to Hypophyseal Tumors.—In both the operation of L. L. McArthur and that of C. H. Frazier for exposure of the hypophysis cerebri the dura mater is elevated with the frontal lobe, and not opened until the dissection has reached the anterior clinoid process. A. W. Adson (Jour. Am. Med. Assoc., Aug. 31, 1918) first had his attention called to the intradural approach by G. H. Heuer. The technic is described as follows: The anesthetic is by the inhalation drop method. The patient is placed on the table with the trunk elevated to an angle of 80 degrees. The head is tilted back to permit the frontal lobe to gravitate back from the anterior fossa. An osteoplastic flap is turned down in the right fronto-temporal region.

The anterior limb of the osteoplastic flap corresponds to the margin of the hair line. The incision passes upward toward the median line 2 cm. from the longitudinal sinus; it then passes backward for 9 cm., and then downward to a point above the middle of the ear. The bone flap is turned down. A flap of dura is cut at right angles to the bone flap, and left in place to cover the cortex. The dura is opened widely. This exposes the frontal lobe of the brain which should then be protected with warm moist cotton covered with rubber tissue. The frontal margin of the dural flap is raised by tension sutures of silk. Gentle elevation of the lobe then exposes the optic commissure and the hypophysis.

Rubber tissue should be placed in strips over the convolutions to protect the cortex as it is elevated by the retractor. The optic commissure and hypophysis are easily exposed. While elevating the anterior lobe of the brain the landmarks in the anterior fossa should be identified. These are the margin of the lesser wing of the sphenoid bone, the right optic nerve, the internal carotid artery, and the anterior clinoid process. The operation is then continued until the commissure, the left optic nerve and the hypophysis are exposed.

Adson cautions that the pledgets of cotton which may be used to control bleeding should be tied to long strings of silk to prevent their loss. He reports six cases operated upon for pituitary tumor. The post-operative convalescence of all was good excepting one which died with leptomeningitis.

The advantages claimed for this operation are that its approach is through a dry field which is free from infection; the optic commissure and the hypophysis are most easily exposed; the removal of the tumor is facile; the commissure and nerves are not traumatized because the sponging is applied against the floor of the sella.

EYELID

For ptosis of the upper eyelid, J. B. Roberts (Surg., Gyn. and Obs., Oct., 1918) used a slip from the occipitofrontalis muscle. A right angular incision is made above the eye on the forehead. A triangular flap is turned back and the frontal part of the occipitofrontalis muscle is exposed. The muscle is divided by a horizontal incision near its frontal insertion. This incision is joined at right angles by two incisions passing upward at either end. The muscle lying between these two vertical incisions is then divided into three oblong segments by adding two more vertical incisions between the first two. An incision is then made transversely across the upper lid. The bridge of skin between the two transverse incisions is undercut. The tarsal cartilage is exposed by dissecting downward. The middle oblong segment of the frontalis muscle is detached by cutting it free above. It is moved downward under the bridge of skin and its lower end sewed to the tarsal cartilage. The lower ends of the two lateral slips of muscle are brought together and the upper end of the displaced segment sewed to their lower ends. This forms a Y of muscle. The extreme lower end is attached to the tarsal cartilage, and the upper ends of the two upper arms have their natural connections.

SPINE

Intravenous Serum Treatment of Epidemic Cerebrospinal Meningitis.—For effective treatment early diagnosis is essential. As the disease is characterized by infection of the blood-stream, intravenous treatment is called for. The usual methods have been to inject 10 to 45 c.c. (0.3 to 1.5 ounces) of serum. This has not given good results. W. W. Herrick (Jour. Am. Med. Assoc., Aug. 24, 1918) in a large experience with the disease among soldiers found the following procedure most effective: The patient is desensitized by a subcutaneous injection of 1 c.c. (15 minims) of serum. At the end of an hour 80 to 150 c.c. ($2\frac{2}{3}$ to 5 ounces) are injected into a vein, the first 15 c.c. ($\frac{1}{2}$ ounce) at the rate of 1 c.c. (15 minims) per minute. The remainder may be permitted to flow in faster. This is massive dosage, but it seems to give results which small dosage has never attained. This particular technic seems to guarantee safety. Severe cases are given this amount of serum intravenously every eight to twelve hours; in mild cases it is given every twenty-four hours. This is continued till the symptoms

subside. The average number of injections required in Herrick's cases was four and a half, and the average total amount of serum given per case is 400 c.c. The largest number of injections required for any single case was twelve. The largest total amount of serum given to any one case was 1500 c.c. (3 pints). This treatment sterilizes the blood. The treatment should be controlled by blood cultures. Positive culture is not found after from one to three large injections of serum.

As soon as meningeal symptoms appear lumbar puncture should be performed about half an hour after the intravenous injection. Enough fluid is removed to reduce the pressure approximately to normal, and 30 c.c. of serum introduced into the spine. Rarely need more than this amount be injected. An average of seven spinal punctures in each case was required in the patients treated by Herrick; and an average of four intraspinal injections. Usually the meningococci are not found after the first forty-eight hours.

During the injections if dyspnea, pallor, cyanosis, vomiting, weak, rapid or irregular pulse develops, the operation should be stopped. The injection may be renewed after two or three hours. Morphin and atropin may be given before the injections, but it is not always necessary. Adrenalin should always be at hand. If intraspinal injections produce extreme discomfort, cause severe pain in the back or legs, or increase the headache or opisthotonos, it is best to omit them.

Intraspinal drainage may be used without injecting serum in cases which show intolerance of the spinal injections. It is best to discontinue the subarachnoid injections if satisfactory response does not follow eight or ten such treatments. Removal of spinal fluid is indicated always for symptoms of increased cerebrospinal pressure.

Relapsing cases should be given the entire cycle of treatment again. The presence of agglutinins in the serum employed may be determined by using the organism cultivated from the blood or spinal fluid. It is of great value that this positive evidence of the specificity of the serum for the particular strain of meningococcus present be obtained. The results of treatment seem to parallel the reaction of the agglutinin content of the serum for the strain of organisms involved. Stock commercial serums are often lacking in high agglutinin content, and for this reason their therapeutic effect is disappointing. If a serum fails to give results, serum from another source should be employed. This is highly important.

The general hygienic treatment of the patient should go along with the serum injections. Morphin or other sedatives should be freely given. Large amounts of morphin are well tolerated. Water in abundance should be given. Alkalies are probably useful. Plenty of food is essential.

THORAX

Resuscitation by Heart Massage.—A new technic of heart massage is reported by T. C. Bost and A. Neve (Lancet, London, Oct. 26, 1918, No. 4965, page 552). An abdominal incision, 10 cm. (4 inches) long, is made in the median line. It extends from above the umbilicus to the apex of the left xiphoid notch. The anterior insertions of the diaphragm are brought into view by strongly retracting the left costal cartilages. A pillow should be placed behind the waist. An incision, 5 cm. (2 inches) long, begins 2.5 cm. (1 inch) to the left of the median line and passes outward behind the costal margin. This incision divides the diaphragm at its anterior insertion. Blunt dissection then opens the pleural cavity. First three fingers are passed in,

and then the whole hand is inserted through the opening. The right hand passes into the thorax in front of the pericardium. The hand passes upward, the thumb is close behind the sternum, and the fingers embrace the entire organ as it lies in the pericardium. With the hand in this position the thumb compresses the right auricle and right ventricle, and the heart is massaged.

This operation does not injure any large blood-vessels. The superior epigastric artery is internal to the incision. Passing down from the internal mammary artery, it sends branches to the rectus muscle, diaphragm, liver, peritoneum, and skin. The branch to the diaphragm passes back through the cellular tissue behind the eighth or ninth costal cartilages, and is deeper than the incision. The pericardium is not opened. By pressing the parts tightly about the operator's wrist, air is not sucked into the pleural cavity. To close the wound the costal margin is retracted and the cut diaphragm is pressed up and a continuous catgut suture is inserted. The abdominal wound is closed by the usual method. (See Heart Massage for Cardiac Syncope, Vol. II, page 430.)

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